

Appendix E2. a – Restoration Plans and TMDLs (Impervious Area Assessment)

Impervious Area Assessment

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Watershed Restoration Status (MS4 Permit 11-DP-3310)



Barry Glassman
County Executive

Complete Projects (pre-2009)

Stormwater and stream restoration - inspections FY2019

Total 95.34

Wpid	Wpname	Wpcomplete (FY)	Total Credits (IA)	Last Inspection	Pass / Fail
WP000040	Pumphrey Property Demolition	2010	0.51	N/A	N/A
WP000003	Laurel Valley Stream Restoration	2009	13.4	12/1/2011	Pass
WP000065	Gilley Property Demolition	2008	0.43	N/A	N/A
WP000002	Laurel Valley SWM Retrofit ¹	2005	19.74	2/14/2018	Fail
WP000001	Laurel Valley Bioretention	2005	1.27	12/21/2018	Pass
WP000007	Harford Center Water Quality Improvments	2005	0.94	6/7/2017	Pass
WP000009	Winters Run at Route 7 Stream Restoration	2004	14.5	4/24/2008	Pass
WP000004	Box Hill South Tributary Stream Restoration	2004	8.1	4/14/2011	Pass
WP000066	Logana Property Demolition	2002	0.46	N/A	N/A
WP000067	Leyko Property Demolition	2002	0.43	N/A	N/A
WP000006	Mt Royal Project SWM Facility ²	2002	35.56	7/25/2017	Fail

¹ HOA maintained, needed repaired no related to retrofit

² Dredging pending summer 2019

Final Report for Identification of Existing Grass Swales – Phase 1



ISO 9001:2000 CERTIFIED

ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS

936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

September 21, 2018

Ms. Christine Buckley
Harford County Department of Public Works
Watershed Protection & Restoration
212 S. Bond Street
Bel Air, MD 21014
(410) 638-3545 ext.1176

Contract No.:	16-153
Contract Name:	On-Call Environmental Design and Assessment
Project No:	171700458
Task Number:	01
Task Name:	Identification of Existing Grass Swales for Harford County
Task Manager:	Christine Buckley

Dear Ms. Buckley:

KCI Technologies is pleased to submit the results of the Desktop Analysis for the Identification of Existing Grass Swales in Harford County. Included is a summary of the submittal package including a summary of the task, process, and results. KCI has also extrapolated the effort from the initial 8 grid tiles for the full County compilation of existing grass swales, including potential saving received for full implementation.

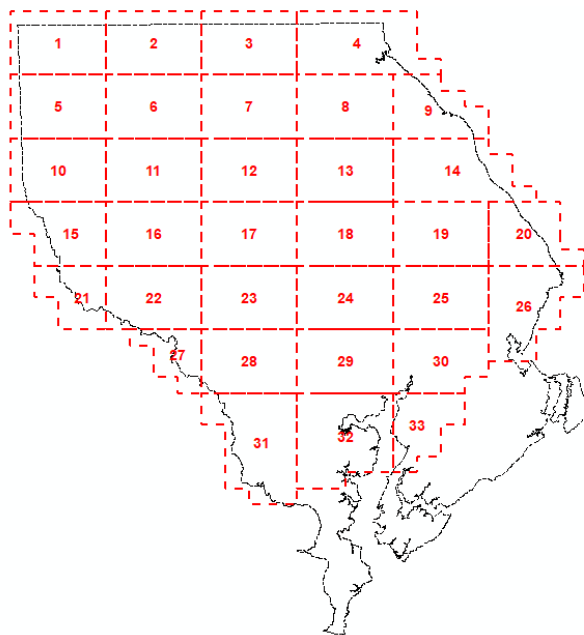
Sincerely,

Brent Reeves
Project Manager

Workflow and Results

KCI was tasked to perform the Desktop Analysis and Engineer Review to identify potential grass swales throughout Harford County. Under this task KCI identified and prepared potential grass swales for field measurements and verification. KCI utilized the MDE approved Existing Water Quality Grass Swale Identification Protocols created by Maryland State Highway Administration. KCI performed the Desktop Processing and Engineer Review / QC of the desktop analysis to identify swales that would be included in a Phase II task to complete field work and full analysis of the drainage and impervious areas. The goal of the grass swale program is to identify grass swales that meet MDE stormwater criteria for impervious treatment. The acres of treatment from the grass swales would be counted as Baseline Impervious Treatment therefor reducing the amount of acres required for the 20% runoff reduction goals.

KCI split Harford County into 33 grid index tiles to improve data processing and review time. KCI ran the desktop models to create flowlines from the County DEM for all 33 index tiles. KCI, with the assistance of the County, identified and prioritized index tiles that had the greatest potential for grass swales. The goal was to identify routes and neighborhoods that had open curb with grass side and median shoulders / runoff areas.



KCI identified that index tile 16, 17, 18, 23, 24, 29, 31, and 32 had the greatest potential for grass swales. Once the grid tiles were prioritized, KCI began the process of cleaning the flow lines for the 8 priority index tiles. KCI removing flow lines behind curbs and that were perpendicular to the roadways. KCI completed the GIS processing and manual review to determine the longitudinal slope, side slopes, and bottom material of the remaining flowlines. Based on these 3 parameters, KCI grouped similar features and categorized the flowlines. The categories are as follows:



ISO 9001:2000 CERTIFIED

ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS

936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

<u>LongSlope</u>	<u>SideSlope</u>	<u>Classify</u>	<u>Category</u>
<4%	<33%	Grass	Category_2A
<4%	33%-50%	Grass	Category_3A
4-6%	<33%	Grass	Category_2B
4-6%	33%-50%	Grass	Category_3B
>6%	<33%	Grass	Category_4A
>6%	33%-50%	Grass	Category_4B
	>50%	Grass	Category_5A
		Not Grass	Category_5B

Water Resource Engineers then performed a QC of the processed flowlines in the 8 priority grid tiles and updated swale limits and categories based on contour review, aerial / StreetView review, and subject matter expertise in grass swale design. KCI packaged the source and resultant data into geodatabases for submittal.

For the 8 index grids, there were ~47,000 flowlines that were categorized. Of these, ~2,400 were categorized as 2A swales, which the engineers reviewed and QCed. KCI engineers also reviewed ~600 category 2B and 4A swales. The 2B and 4A swales only fail because of a greater longitudinal slope. KCI has found from working on other county grass swale projects that the longitudinal slope calculated during the Desktop Analysis is conservative. KCI identified based on engineer review of the longitudinal slope that some of the 2B and 4A categories may have a slope that is boarder line to <4% and may be providing treatment. KCI engineers updated the 2B and 4A category to a category 2A if it was determined that the slope may be valid for treatment.

Of the ~3,000 grass swales reviewed and QCed by engineers, 586 remained as category 2A swales. These 586 potential grass swales are the swales that would be field verified, have a cross section survey, and a drainage area delineation to determine if the swales indeed meet MDE criteria. The attached table identifies the swale numbers through each phase of the Desktop Analysis.

Cost Analysis

Based on other similar grass swale projects, KCI anticipated that 60% of the 586 swales that are field verified will fail based on field conditions or drainage area size. Therefor it is anticipated that 234 swales will meet MDE's design criteria for treatment. KCI anticipates that each swale will have 0.25 acres of impervious within the drainage area for a total of 58.60 acres of impervious. Of the 58.60 acres, 20% of the acreage can be claimed as baseline treated impervious. KCI anticipates that for the 8 priority index tiles a total of 11.72 baseline treated impervious acres (see attached table) can be claimed.

For the 8 priority index tiles, the cost to complete Phase I (Desktop Analysis) and Phase II (Field Verification and Full Analysis) for 11.72 acres of baseline treatment is estimated to be ~\$327,500.00. Harford County indicated that 1 acre of restoration credit costs~\$55,000.00;



ISO 9001:2000 CERTIFIED

ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS

936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

therefore the equivalent restoration cost for 11.72 acres would be ~\$644,600.00. The anticipated saving by claiming the grass swale baseline credit is ~\$317,000.00.

8 Tile Cost Savings	
Baseline Credit for 8 Tiles	11.72
Phase I Cost (Desktop Analysis)	\$109,028.00
Phase II Cost (Field / Post Field)	\$218,488.00
Total Cost to Completed 8 Tiles	\$327,516.00
Restoration Cost per Acre	\$55,000.00
Equivalent Restoration Cost	\$644,600.00
Anticipated Savings for 8 Tiles	\$317,084.00

KCI extrapolated the cost and acres determined from the 8 priority index tiles for the remaining 25 index tiles not yet processed. Since the remaining 25 index tiles are not the best candidates for grass swales KCI implemented a 25% reduction in the number of baseline treatment credit acres in anticipation of having lesser results. KCI estimated from the 8 priority index tiles that 1.47 acres of baseline treatment resulted per index tile. With a 25% reduction across 25 index tiles, the County can anticipated ~27.50 additional baseline credit acres resulting from the full desktop analysis, field verification, and post field analysis of the 25 remaining index tiles. It is estimated that the total cost to complete the full grass swale workflow for the remaining 25 index tiles including desktop analysis, field verification, and post field analysis would be ~\$1,023,500.00. The equivalent cost for 27.50 acres of restoration design would be ~\$1,510,700.00. The anticipated saving by claiming the grass swale baseline credit for the remaining 25 index tiles would be ~\$487,000.00.

25 Remaining Tile Cost Savings	
Average Baseline Credit Acres per Tile	1.47
Remaining Tiles	25
Anticipated Total Baseline Acres	36.63
Reduction % for Second Tier Tiles	25%
Anticipated Total Baseline Acres (25% Reduction)	27.47
Average Cost per Tile	\$40,939.50
Total Cost Remaining Tiles	\$1,023,487.50
Equivalent Restoration Cost	\$1,510,781.25
Anticipated Savings for 25 Tiles	\$487,293.75



When the total cost to complete the full countywide analysis is calculated and compared to the equivalent cost for restoration credit, a ~\$800,000.00 in saving is anticipated.

Full County Cost Savings	
Full County Baseline Credit Acres	39.19
Full County Analysis Cost	\$1,351,003.50
Equivalent Restoration Cost (Full County)	\$2,155,381.25
Anticipated Savings Full County	\$804,377.75

GIS Data Submittal

KCI packaged the GIS source data and the resultant data. The data resides on the external memory stick and includes (HarfordCo_GrassSwale_Results_20180921.zip):

Source Data (HarfordCo_SourceData.gdb)

- Contours – 2 foot elevation contours
- Grid_Index_DEM – 33 tile grid index
- HA_Impervious2000 – Harford County impervious layer
- HA_SDpipes – Harford County storm drain conveyance
- HA_SDpoints – Harford County storm drain features / structures
- HA_SidewalkThru2007 – Harford County sidewalks layer
- HA_StormDrainArea – Harford County drainage areas
- HA_StreetCenterline – Harford County street centerline
- HA_StreetCenterline_Buffer_250 – 250' buffer around the street centerline features. KCI used the buffer to complete an initial erase of any flowlines outside the buffer.
- HA_SWM_BMPs – Harford County BMP layer
- Streams – Harford County stream layer

Resultant Data (HarfordCo_GrassSwale_Results_20180921.gdb)

- HaCo_GS_Flowline data set – initial raw flowlines generated from the DEM layer for each of the 33 index tiles
- Index 16_Final data set – includes a feature class layer containing all the categorized flowlines, and a feature class layer of just the 2A swales for that index. There is a layer data set for each of the 8 priority index tiles.
- HAcO_GS_2A_Swales_ALL – combined feature class layer containing all of the 2A swales from the 8 priority index tiles.

Please let me know if you have any questions, or when KCI and the County could meet to discuss the results and next steps.

Index	Status	Total Initial Flowline	Total Swale after Desktop Analysis	Total 2A Swale after Desktop Analysis	Total 2B and 4A Swales	Total Swale Reviewed By Engineer	Total 2A Swale after Engineer Review	60 % Reduction After Field / Post Field Analysis	0.25 Acres Treatment	Total Acres	Total Baseline Credit (20% Total Acres)
1	Initial Flowlines Generated	173,637									
2	Initial Flowlines Generated	176,750									
3	Initial Flowlines Generated	168,775									
4	Initial Flowlines Generated	215,473									
5	Initial Flowlines Generated	181,170									
6	Initial Flowlines Generated	178,676									
7	Flowlines Clipped	175,697									
8	Initial Flowlines Generated	164,524									
9	Initial Flowlines Generated	131,043									
10	Initial Flowlines Generated	178,835									
11	Flowlines Clipped	176,605									
12	Initial Flowlines Generated	180,900									
13	Initial Flowlines Generated	168,903									
14	Initial Flowlines Generated	218,278									
15	Initial Flowlines Generated	150,049									
16	QC Complete	178,317	3,825	276	125	401	60	24	0.25	6	1.2
17	QC Complete	162,885	300	50	48	98	31	12	0.25	3.1	0.62
18	QC Complete	171,623	4,054	488	59	547	131	52	0.25	13.1	2.62
19	Initial Flowlines Generated	165,504									
20	Initial Flowlines Generated	127,236									
21	Initial Flowlines Generated	109,964									
22	Flowlines Clipped	175,239									
23	QC Complete	154,007	9,908	168	67	235	89	36	0.25	8.9	1.78
24	QC Complete	159,221	7,959	230	44	274	73	29	0.25	7.3	1.46
25	Initial Flowlines Generated	148,652									
26	Initial Flowlines Generated	169,692									
27	Initial Flowlines Generated	88,384									
28	Initial Flowlines Generated	160,552									
29	QC Complete	153,189	9,018	420	55	475	40	16	0.25	4	0.8
30	Initial Flowlines Generated	138,497									
31	QC Complete	211,358	6,116	454	145	599	94	38	0.25	9.4	1.88
32	QC Complete	204,537	6,090	345	73	418	68	27	0.25	6.8	1.36
33	Initial Flowlines Generated	106,851									
		5,425,023	47,270	2,431	616	3,047	586	234		58.60	11.72

Scope of Work for Identification of Existing Grass Swales – Phase 2

BARRY GLASSMAN
HARFORD COUNTY EXECUTIVE

BILLY BONIFACE
DIRECTOR OF ADMINISTRATION



KAREN D. MYERS, CPPB
DIRECTOR OF PROCUREMENT

DEPARTMENT OF PROCUREMENT

VIA EMAIL: kerry.rexroad@kci.com

October 23, 2018

KCI Technologies
ATTN: Kerry Rexroad
936 Ridgebrook Road
Sparks, Maryland 21152

RE: 16-153 – Environmental Design and Assessment On-Call Contract
16-153R – Identification of Existing Grass Swales for Harford County, Phase II

Dear Mr. Rexroad:

I am writing to inform you that your proposal for the Identification of Existing Grass Swales, Phase 2 in the amount of \$218,488.70 has been approved. The notice to proceed date for this project is today (October 23, 2018). The Purchase Order for the project is DP1901462.

Finally, the project manager is Christine Buckley with DPW.

Very truly yours,

Christine H. Carpenter
Purchasing Agent II

CHC/vfy

cc: Christine Buckley – DPW/Engineering

MARYLAND'S NEW CENTER OF OPPORTUNITY

410.638.3550 | 410.879.2000 | TTY Maryland Relay 711 | www.harfordcountymd.gov

220 South Main Street, Bel Air, Maryland 21014

THIS DOCUMENT IS AVAILABLE IN ALTERNATIVE FORMAT UPON REQUEST



ISO 9001:2000 CERTIFIED

ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS

936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

April 25, 2018

Ms. Christine Buckley
Harford County Department of Public Works
Watershed Protection & Restoration
212 S. Bond Street
Bel Air, MD 21014
(410) 638-3545 ext.1176

Contract No.:	16-153
Contract Name:	On-Call Environmental Design and Assessment
Project No:	171700458
Task Number:	07
Task Name:	Identification of Existing Grass Swales for Harford County – Phase II
Task Manager:	Christine Buckley

Dear Ms. Buckley:

At the request of Ms. Christine Buckley, KCI Technologies, Inc. (KCI) is pleased to submit the attached scope and price proposal to complete Task 07 - Identification of Existing Grass Swales for Harford County – Phase II under Contract No. 16-153. The budget for Task 07 services totals \$218,488.70. This proposal will be a continuation of where Task 01 (Desktop Analysis / QC) left off. This proposal will cover the completion of the field measurement / verification of grass swales identified during the Desktop Analysis, the Engineer review of field results, the full analysis of swales to determine if the potential swale meets MDE design criteria, and final submittal / summary report of the final analysis. It is anticipated that this scope of work will be completed for up to 600 swales, identified during Phase I – Desktop Analysis efforts already completed under Task 01. KCI anticipates completion of the task within approximately 6 months after notice to proceed is granted.

We are available to discuss any details of this proposal with you at your convenience. Thank you for your consideration, and we look forward to performing these services for the Harford County.

Sincerely,

Kerry Rexroad, PE
Vice President, Water Resources

cc: Ms. Christine Buckley / Harford County DPW
Mr. James Tomlinson, PE / WR Practice Leader
Mr. Jeff Tirschman / Regional Practice Leader

SCOPE OF WORK

As an element of Harford County's Chesapeake Bay Restoration Plan, Harford County is completing a project to identify the locations and assessing the effectiveness of existing grass swales. Establishing a current and correct list of grass swales will allow Harford County to collect and document the baseline credit reduction for the impervious surface treatment provided by the grass swales, ultimately reducing the County's 20% impervious restoration requirement in the NPDES permit.

Under Task 1 of CONTRACT #16-153 KCI utilized the Existing Water Quality Grass Swale Identification Protocol approved by MDE on May 18, 2016, and established by Maryland State Highway Administration and KCI, to begin the process to identify valid swales that meet MDE's design criteria. Under Task 1 KCI performed the Desktop Analysis and Engineer Review that identified approximately 600 potential grass swales that will require field verification / measurements and full engineering analysis to determine if these swales meet MDE's full design criteria. KCI will continue to utilize the operating procedures and analysis table (Table C1, C2, & C3) outlined in the Existing Water Quality Grass Swale Identification Protocol, and lessons learned from previous grass swale projects, to complete the field and final analysis.

The following proposal, submitted by KCI Technologies, Inc. (KCI) describes our suggested approach to perform the field verification / measurements and full criteria analysis for up to 600 potential grass swales derived from the Desktop Analysis. The following are the primary services to be provided under this scope of work:

- Field verify potential grass swales and measure / record a cross section for each "swale" that exists in the field.
- Complete post field engineering analysis to determine if the potential swale meets MDE's design criteria.
- Submit the results and a procedures report indicating acres of baseline impervious reduction.

TASK 1: PROJECT INITIATION / MEETINGS

Upon receipt of notice to proceed, KCI will meet with Harford County to discuss the project and kick off the work effort. Discussion topics during this initial meeting will include:

- Materials and available information to be supplied by Harford County.
- Communications plan.
- Project schedule.
- Deliverables.
- Field work and post field work workflows.
- Submission procedures / requirements.

KCI anticipates having up to four (4) progress meetings with Harford County to discuss the progress of the project. The purpose of the progress meeting is to discuss the project status, budget, schedule, and hindrances. The progress meetings may be online or in person meetings, at the County's preference. KCI will prepare agendas to outline the topics for discussion and will identify stakeholders required to be present. Following each meeting, the project manager will complete and distribute meeting minutes to all meeting attendees. The minutes will be distributed within five (5) business days after the progress meeting.

KCI will also deliver project updates in the form of monthly progress reports, which will indicate the project completion percentage and dollars remaining as of the date of submission. At a minimum, progress reports will detail the following:

- Number of potential swales field verified
- Number of swales meeting full MDE criteria
- Number of credit acres for baseline reduction

Deliverables

- *Kickoff agenda and meeting minutes*
- *Progress meeting agenda and meeting minutes*
- *Monthly progress reports*

TASK 2: PRE-FIELD ORGANIZATION

KCI will perform tasks leading up to the field work effort. These tasks include mapping the sites, setting up hardware and software and other equipment, and performing the day-to-day field planning and coordination.

Mapping

KCI will create 11" x 17" color hardcopies of each potential grass swale site. To minimize hardcopy mapping, KCI will include multiple swales on each map as location and scale allows. The field map will include at a minimum the swale ID, swale geometry based on desktop analysis, Harford County storm drain, 2-foot elevation contours, and aerial imagery.

The maps will be used by the field team to mark up the drainage area delineation boundary for each swale on the map. Field staff will mark up the field maps with details and updated related to the drainage area, storm drain system, runoff flow directions, and / or the swale geometry itself. The resultant marked up field maps will assist with data QC during post field work tasks. The field maps will be used by the data quality control teams and engineers while reviewing the field results and drainage area delineation. Upon completion of the field work, the field maps will be scanned and provided as a deliverable.

Hardware / Software Setup / Equipment

KCI will utilize tablets with Collector and Survey 123 to capture the grass swale cross section measurements in the field. KCI will ensure that the proper feature service is set up and that field crews have access to push field results. KCI will enter test inspection records in Survey123 to ensure that the field results are pushed to the feature service correctly. KCI will also purchase and gather any of the require field and safety equipment for the field work.

Field Planning

KCI will coordinate the field crews and equipment for the day-to-day activities. This includes reviewing the sites for upcoming field work to identify safe parking and / or issues with the site that may impede a cross section measurement, ensuring access to the feature service, ensuring that meeting times and weather are confirmed, and that equipment is in place for the field work. KCI will plan the day-to-day routing so that little overlap occurs. The goal of this task is the make sure the field work is as efficient and consistent as possible.

Deliverables

- *Field maps with drainage information and drainage area delineation mark ups.*

TASK 3: FIELD VERIFICATION

KCI will perform the field verification, cross section measurements, and the quality control of the field data entry for up to 600 potential grass swales identified during the Desktop Analysis.

Field Verification

KCI will mobilize field crews to verify if a "swale" / "ditch" exists in the field. If a swale / ditch does not exist, field crews will note the reason as such and not further field action will be required. If a swale / ditch exists, field crews will:

- Verify the limits of the swale and make corrections on the field map.
- Determine the location of the cross section and mark on the field map.
- Set up the tape cross section and measure the cross section and longitudinal slope using a hand level.
- Enter the cross section information and swale details using Survey123 application
- Mark up the field map with the drainage area boundary, specifically within the roadway focusing on identifying the crown of the road (drainage area finalization will be completed in Task 4 of this proposal).
- Photograph the potential grass swale.

It is anticipated that two (2) KCI field staff can field verify / measure twelve (12) potential grass swales in one (1), nine (9) hour day.

QC of Field Verification

KCI will download the Survey123 cross section data, will download the photographs, and will generate Table C1 which includes the field measurement date. The team will perform quality control on the field data from Table C1 to look for data anomalies, incomplete data, or data conflicts. The team will ensure that the drainage area was delineated correctly and is legible on the hardcopy field map. Additional field verification will be conducted, as needed, to resolve data issues.

Deliverables

- *Cross section and swale detail / measurements*
- *Photographs of swales*
- *Table C1 / Table C1 Quality Control*

TASK 4: POST FIELD COMPILATION AND SUBMITTAL

KCI will perform tasks related to full data analysis of the field verification. These tasks include finalizing drainage areas, updating impervious layers, performing final full analysis, and providing a submittal of swales that meet the full MDE criteria.

Drainage Area & Impervious Area Delineation

KCI will utilize the field maps with the drainage area boundary delineation and engineering analysis to complete and finalize the drainage area delineation for swales that are still potential after field verification. GIS staff will finalize the drainage areas into GIS polygon feature class and will associate the swale ID to the drainage areas. The drainage area acreage will be auto-calculated in ArcMap and the acreage will be populated in an attribute field in the drainage area GIS feature class. GIS staff will delineate any missing impervious areas within the drainage area. The impervious area within the drainage area will be calculated and populated in an attribute field per swale. The drainage area and impervious area acres will be used in Table C2 to help determine if the potential swale meets MDE criteria.

Analysis Table Completion

The team will make any necessary swale geometry edits based field observation. The drainage area, impervious area, swale length, and other engineering parameters will be entered and used in Table C2 and Table C3 to make the final determination if the swale meets MDE criteria. The automated tables (Table C2 & C3) results, with engineering review will indicate if the swales meet the criteria. The team will update any swale ID's and categories as needed based on the results. The team will also ensure that the swale ID is correct on all associated photographs, field maps, and field forms.

Final Analysis

KCI will run an advanced grass swale analysis process and form to reclaim additional, legitimate credit that the conservative assumptions in the protocol fail to claim. Grass swale engineering parameters that do not meet the MDE design criteria based on the output of analysis Tables C2 and C3 will be run in the advanced grass swale analysis spreadsheet. This spreadsheet is meant to be less conservative than the original protocol, and has been accepted by the engineering community working on similar grass swale projects. The engineer will enter the swale attribute and determine if any additional credit can be counted. The team will update the swale ID's and categories as needed.

Submittal / Reporting

KCI will create a polygon swale layer of the swales that meet MDE criteria. KCI will package the swales, drainage areas, impervious areas, and analysis tables into a submittal. The submittal package will be quality control checked for completeness by GIS and engineering staff. The package will include the final impervious areas for credit in a polygon GIS layer associated per swale.

KCI will provide the County with standard operating procedure text for the annual report. This will include a discussion / report of the process and results of the project.

Deliverables

- *Final drainage and impervious layers*
- *Data analysis tables*
- *Final swale layer*
- *Process and results report*

ASSUMPTIONS

The following assumptions have been made in the development of this proposal:

- Project execution will follow the Existing Water Quality Grass Swale Identification Protocol approved by MDE on May 18, 2016, protocol appendices, and lessons learned during previous swale task.
- The resultant grass swale will be in compliance with the protocol and will meet / exceed the criteria of a MDE M-8 grass channel.
- All GIS submittals shall be ArcGIS 10 compatible and based on Maryland State Plane Projection.
- An H&H Engineer will be responsible for the final deliverables and category values assigned to the potential grass swales

MANHOUR ESTIMATES

TASK DESCRIPTION	Project Manager	WR Engineer	CADD / GIS Technician	Professional Land Survey	TOTAL
Task 1 - Project Initiation / Meetings					
Kickoff / Progress Meeting(s)	20	20		20	60
Task 2 – Pre-Field Organization					
Mapping	8	8	134		150
Hardware / Software Setup / Equipment	8		32		40
Field Planning	4		46		50
Task 3 – Field Verification					
Field Verification	40	450	450		940
QC of Field Verification			50		50
Task 4 – Post Field Compilation and Submittal					
Drainage Area and Impervious Area Delineation	8	190	160	8	366
Analysis Table Completion	8	60	100	40	208
Final Analysis	8	24		126	158
Submittal / Reporting	40	20		40	100
TOTAL	144	772	972	234	2,122
Directs = \$3,419.50; Directs charged in conjunction with Task 3 - Field Verification					

- It is anticipated that approximately 600 potential grass swales will be field measured / verified and will be fully analyzed, as needed, to determine if the potential swale meets MDE's criteria.
- It is assumed that two (2) KCI field staff can field verify / measure twelve (12) potential grass swales in one (1), nine (9) hour day.

SCHEDULE

KCI will execute the task with completion and submission of all deliverables within approximately 6 months after the kickoff meeting.

COSTING

The total lump sum, fixed fee amount for the scope contained herein is **\$218,488.70**. KCI will employ approved contract bill rates, and monthly invoicing amounts will be based on a percent complete total derived from the completion of each task. The manhour table following this page supports the pricing below

TASK DESCRIPTION	TASK TOTAL	PERCENT
Task 1 - Project Initiation / Meetings		
Kickoff / Progress Meeting(s)	\$8,600.00	3.94%
Task 2 – Pre-Field Organization		
Mapping	\$12,732.40	5.83%
Hardware / Software Setup / Equipment	\$3,915.20	1.79%
Field Planning	\$4,315.60	1.98%
Task 3 – Field Verification & Directs		
Field Verification	\$90,789.50	41.55%
QC of Field Verification	\$3,930.00	1.80%
Task 4 – Post Field Compilation and Submittal		
Drainage Area and Impervious Area Delineation	\$34,216.00	15.66%
Analysis Table Completion	\$21,460.00	9.82%
Final Analysis	\$23,330.00	10.68%
Submittal / Reporting	\$15,200.00	6.96%
TOTAL	\$218,488.70	100.00%

TASK DESCRIPTION	Bill Rate					WR Engineer	CADD / GIS Technician	Professional Land Survey	HOUR TOTAL	TASK TOTAL
	\$	\$	\$	\$	\$					
Task 1 - Project Initiation / Meetings	\$ 3,500.00	\$ 175.00	\$ 100.00	\$ 78.60	\$ 155.00					
Kickoff / Progress Meeting(s)	20		20		20				60	\$ 8,600.00
Task 2 - Pre-Field Organization	\$ 3,500.00	\$ 175.00	\$ 800.00	\$ 16,663.20	\$ -					\$ 20,963.20
Mapping	8		8	134					150	
Hardware / Software Setup / Equipment	8			32					40	
Field Planning	4			46					50	
Task 3 - Field Verification	\$ 7,000.00	\$ 350.00	\$ 45,000.00	\$ 39,300.00	\$ -					\$ 91,300.00
Field Verification	40		450	450					940	
QC of Field Verification				50					50	
Task 4 - Post Field Compilation and Submittal	\$ 11,200.00	\$ 560.00	\$ 29,400.00	\$ 20,436.00	\$ 33,170.00					\$ 94,206.00
Drainage Area and Impervious Area Delineation	8		190	160	8				366	
Analysis Table Completion	8		60	100	40				208	
Final Analysis	8		24		126				158	
Submittal / Reporting	40		20		40				100	
TOTAL	144		772	972	234				2122	\$ 215,069.20
<i>Total by Classification \$ 25,200.00 \$ 77,200.00 \$ 76,399.20 \$ 36,270.00</i>										
Total Labor									\$ 215,069.20	

Harford County Grass Swale - Phase II - Directs										
Number Field Verification			600	Cents per Mile						\$0.545
11x17 color each BMP			2	Miles round trip						60
Total Field Maps			1200	10 Additional Miles/Field Day						10
Total 8.5 x 11 BW			200	Total Miles per Day						70
Cost per 11 x 17 Color				Total Field Days						50
Cost per 8.5 x 11 BW				Total Miles						3,500
Total Field Maps				Total Mileage						\$1,907.50
Total 8.5 x 11 BW										
Total Print				Total Directs *Included in Field Verification Task 3						\$ 3,419.50

Total Task	\$218,488.70
-------------------	---------------------

buckley, christine

From: Brent Reeves <Brent.Reeves@kci.com>
Sent: Tuesday, October 02, 2018 8:21 AM
To: buckley, christine; James Tomlinson
Cc: Jeff Tirschman; Matthew Snyder
Subject: RE: Grass Swale Phase II, Task Proposal #7
Attachments: HACO_GrassSwale Phase II - Proposal Rates - 2018_10_02.xlsx

Christine,

Bill rates are below & attached. As well, KCI's response for your request for more details about the Final Analysis under Task 4.

	Bill Rate	\$ 175.00	\$ 100.00	\$ 75.60	\$ 155.00		
TASK DESCRIPTION	Project Manager	WR Engineer	CADD / GIS Technician	Professional Land Survey	HOUR TOTAL	TASK TOTAL	
Task 1 - Project Initiation / Meetings	\$ 3,500.00	\$ 2,000.00	\$ -	\$ 3,100.00		\$ 8,600.00	
Kickoff / Progress Meeting(s)	20	20		20	60		
Task 2 - Pre-Field Organization	\$ 3,500.00	\$ 800.00	\$16,663.20	\$ -		\$ 20,963.20	
Mapping	8	8	134		150		
Hardware / Software Setup / Equipment	8		32		40		
Field Planning	4		46		50		
Task 3 - Field Verification	\$ 7,000.00	\$45,000.00	\$39,300.00	\$ -		\$ 91,300.00	
Field Verification	40	450	450		940		
QC of Field Verification			50		50		
Task 4 - Post Field Compilation and Submittal	\$11,200.00	\$29,400.00	\$20,436.00	\$33,170.00		\$ 94,206.00	
Drainage Area and Impervious Area Delineation	8	190	160	8	366		
Analysis Table Completion	8	60	100	40	208		
Final Analysis	8	24		126	158		
Submittal / Reporting	40	20		40	100		
TOTAL	144	772	972	234	2122	\$ 215,069.20	
<i>Total by Classification</i>	\$ 25,200.00	\$ 77,200.00	\$ 76,399.20	\$ 36,270.00			
					Total Labor	\$ 215,069.20	

Harford County Grass Swale - Phase II - Directs			
Number Field Verification	600	Cents per Mile	\$0.54
11x17 color each BMP	2	Miles round trip	60
Total Field Maps	1200	10 Additional Miles/Field Day	10
Total 8.5 x 11 BW	200	Total Miles per Day	70
Cost per 11 x 17 Color	\$1.25	Total Field Days	50
Cost per 8.5 x 11 BW	\$0.06	Total Miles	3,300
Total Field Maps	\$1,500.00	Total Mileage	\$1,907
Total 8.5 x 11 BW	\$12.00		
Total Print	\$1,512.00	Total Directs *Included in Field Verification Task 3	\$ 3,41
		Total Task	\$218.48

The existing grass channels that are de-classified after field verification and post field analysis based on a number of different parameters are designated as "XX" swales. The XX swales that are field verified, but fail based on the output of analysis Tables C2 and C3, will be further analyzed to determine if the swale meets MDE's design criteria using actual

channel cross-section geometry. The majority of existing grass channels are parabolic in shape, and the equivalent flat bottom width will be determined for each XX swale with an irregular cross-section geometry using the same methods described in Step 3.2.4 [Equivalent Flat Bottom Width] of the Existing Water Quality Grass Swale Identification Protocol. For the XX swales that have a trapezoidal cross-section geometry, the bottom width as determined during the field verification process will be used. The water quality flow depths and velocities will be calculated using Manning's equation, and each swale will be evaluated to determine if it meets the criteria to be designated a 2A swale.

For those XX swales that have flow depths that still exceed 4" after further analysis, the swale will be evaluated to determine if shortening the swale, thus reducing the drainage area, will result in a viable 2A swale. For example, an XX swale that is 800' long may pass all criteria except the flow depth, but shortening the swale (moving the Point of Investigation upstream) to 500' would result in a reduction in contributing drainage area, reducing the flow depth to less than 4", and thus producing a viable 2A swale.

Previous results from other jurisdictions have indicated that the additional credit gained from the advanced grass swale analysis is about equal to the credit gained from the swales that pass based on the output of analysis Tables C2 and C3. The advanced analysis is expected to double the credit gained by validating swales lost through the very conservative approach of the C2 and C3 tables used in the Grass Swale Protocols.

Let me know if you need further clarification.

Brent

From: buckley, christine [mailto:cmbuckley@harfordcountymd.gov]
Sent: Friday, September 28, 2018 12:24 PM
To: James Tomlinson <James.Tomlinson@kci.com>; Brent Reeves <Brent.Reeves@kci.com>
Subject: RE: Grass Swale Phase II, Task Proposal #7

Couple of questions for the enclosed proposal. I need the hourly rates used to develop the costs. And I would like more detail about the final analysis. It seems like a large number of hours to me.

From: buckley, christine
Sent: Friday, July 13, 2018 2:19 PM
To: 'James Tomlinson' <James.Tomlinson@kci.com>
Cc: 'Brent Reeves' <Brent.Reeves@kci.com>; kearby, scott <sakearby@harfordcountymd.gov>
Subject: RE: Grass Swale Phase II, Task Proposal #7

One other question. Based on phase 1 and past projects, what would our ballpark estimate be on credits?

From: buckley, christine
Sent: Friday, July 13, 2018 2:14 PM
To: 'James Tomlinson' <James.Tomlinson@kci.com>
Cc: 'Brent Reeves' <Brent.Reeves@kci.com>
Subject: RE: Grass Swale Phase II, Task Proposal #7

Just one question at this time - Are we still looking to identify 3,000 swales in the 2A category from Phase 1? If so, what is the process for selecting 600 from the 3,000?

From: James Tomlinson <James.Tomlinson@kci.com>
Sent: Wednesday, April 25, 2018 5:23 PM

To: buckley, christine <cmbuckley@harfordcountymd.gov>

Subject: Grass Swale Phase II, Task Proposal #7

Christine,

Attached is KCI's proposal for Phase II of the grass swale study. This is being submitted as Task 07 under our existing On-Call Environmental Design and Assessment contract, 16-153. Please review the attached and if you have any questions, please let me know. We appreciate the opportunity to continue this work.

Thanks,

James A. Tomlinson, PE

Senior Associate, Water Resources Practice

KCI Technologies, Inc.

936 Ridgebrook Road

Sparks, MD 21152

(410) 316-7864

Watershed Restoration Projects

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Watershed Restoration Status (MS4 Permit 11-DP-3310)



Barry Glassman
County Executive

	Thru FY2015	FY2016	FY2017	FY2018	FY2019	FY2020	Total
Septic Pump Out (Average per year)	323.5	309.0	296.7	300.3	300.0	300.0	300.2
Connections to WWTP	17.6	3.5	3.1	3.5	3.0	3.0	33.7
Septic BAT Installation	25.2	17.9	10.7	4.7	7.0	7.0	72.5
Restoration	91.3	22.3	24.9	113.2	72.0	167.8	491.5
Total	457.6	352.7	335.3	421.8	382.0	477.8	897.8

Note: All values are impervious acres calculated using methods outlines in the "Accounting for Stormwater Wasteload Allocations and Impervious Acres Treated", MDE 2014

Target = 20% 2,218.0

Balance 1,320.2

Target = 10% 1,109.0

Balance 211.2

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Completed Capital Improvement Projects (FY2018)



Barry Glassman
County Executive

Abingdon Library Water Quality Improvements (WP000070)

Design Initiated - Apr 2016 Construction Completed - Nov 2017

2510 Tollgate Road (ADC (2012) 49F5)

New micro-bioretention, tree planting, conversion of existing detention pond to infiltration basin

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
\$42,777 (20%)	\$173,114 (80%)	\$215,891	\$0 (0%)	3.72 acres	\$58,035

CIPid	Credits Type	Drainage Area (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0098	Pervious Urban to Forest		1.41 acres	0.54	0.38 ac imp per 1 ac planted
CIP0099	SWM Facility (RR)	0.89 (18%)	1.46 " rainfall treated	0.18	1 ac imp per 1" rainfall treated
CIP0070	SWM Retrofit (RR)	8.3 (37%)	1.56 " rainfall treated	3.00	1 ac imp per 1" rainfall treated

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Completed Capital Improvement Projects (FY2018)



Barry Glassman
County Executive

Bear Cabin Branch Wetland and Stream Restoration (WP000074)

Design Initiated - Sep 2016 Construction Completed - May 2018

Near intersection of Grafton Shop Road and Timberlea Drive (ADC (2012) 40E3)

Stream restoration, wetland restoration

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
\$140,873 (13%)	\$949,127 (87%)	\$1,090,000	\$775,000 (71%)	36.75 acres	\$29,660

CIPid	Credits Type	Drainage Area (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0074	Stream Restoration		3675 feet	36.75	0.01 ac imp per liner foot

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Completed Capital Improvement Projects (FY2018)



Barry Glassman
County Executive

Leight Center Parking Lot Green Infrastructure (WP000046)

Design Initiated - Nov 2015 Construction Completed - Nov 2017

700 Otter Point Road (ADC (2012) 57D2)

Two micro-bioretenction, permeable pavers

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
\$33,966 (12%)	\$243,484 (88%)	\$277,450	\$125,000 (45%)	0.41 acres	\$676,706

CIPid	Credits Type	Drainage Area (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0102	SWM Facility (RR)	0.1 (100%)	1 " rainfall treated	0.10	1 ac imp per 1" rainfall treated
CIP0046	SWM Facility (RR)	0.22 (59%)	1.28 " rainfall treated	0.14	1 ac imp per 1" rainfall treated
CIP0103	SWM Facility (RR)	0.27 (48%)	2.3 " rainfall treated	0.17	1 ac imp per 1" rainfall treated

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Completed Capital Improvement Projects (FY2018)



Barry Glassman
County Executive

Lower Wheel Creek SWM Retrofit & Stream Restoration (WP000027)

Design Initiated - Jan 2011 Construction Completed - Nov 2017

Near intersection of Wheel Road and Arthur Woods Drive (ADC (2012) 49F4)

Stream restoration, four stormwater wetlands

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
\$326,914 (16%)	\$1,777,050 (84%)	\$2,103,964	\$1,420,177 (68%)	52.12 acres	\$40,368

CIPid	Credits Type	Drainage Area (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0075	Stream Restoration		1939 feet	19.39	0.01 ac imp per liner foot
CIP0027	Stream Restoration		2431 feet	24.31	0.01 ac imp per liner foot
CIP0077	SWM Facility (ST)	12.6 (33%)	0.6 " rainfall treated	2.51	1 ac imp per 1" rainfall treated
CIP0078	SWM Facility (ST)	19.41 (38%)	0.27 " rainfall treated	1.98	1 ac imp per 1" rainfall treated
CIP0076	SWM Facility (ST)	10.69 (35%)	0.68 " rainfall treated	2.53	1 ac imp per 1" rainfall treated
CIP0079	SWM Facility (ST)	6.07 (38%)	0.61 " rainfall treated	1.40	1 ac imp per 1" rainfall treated

Harford County, MD Department of Public Works
Watershed Protection and Restoration
Completed Capital Improvement Projects (FY2018)



Barry Glassman
County Executive

Ring Factory ES SWM Retrofit & Stream Restoration (WP000035)

Design Initiated - Sep 2014 Construction Completed - Jun 2018

1400 Emmorton Road (ADC (2012) 41F8)

Stream restoration, outfall stablization, convert two existing detention ponds to stormwater wetlands

Design	Construction	Total Cost	Grant	Credits	Cost per Impervious Acre
\$293,637 (20%)	\$1,196,949 (80%)	\$1,490,585	\$660,132 (44%)	20.23 acres	\$73,682

CIPid	Credits Type	Drainage Area (acres) / Impervious	Project Size	Credits (acres)	Credit Value
CIP0101	Outfall Stablization		84 feet	0.84	0.01 ac imp per liner foot
CIP0100	Stream Restoration		1055 feet	10.55	0.01 ac imp per liner foot
CIP0035	SWM Retrofit (ST)	31.15 (28%)	1.05 " rainfall treated	8.84	1 ac imp per 1" rainfall treated

Harford County, MD Department of Public Works
 Watershed Protection and Restoration
 Watershed Restoration Status (MS4 Permit 11-DP-3310)



Barry Glassman
 County Executive

Complete Projects

Tree planting - inspections FY2019
Stormwater and stream restoration - inspections FY2019

Total 251.69

Wpid	Wpname	Wpcomplete (FY)	Total Credits (IA)	Last Inspection	Pass / Fail
WP000027	Lower Wheel Creek SWM Retrofit & Stream Restoration	2018	52.12	4/22/2017	Pass
WP000046	Leight Center Parking Lot Green Infrastructure	2018	0.41	11/17/2017	Pass
WP000070	Abingdon Library Water Quality Improvements	2018	3.72	10/19/2017	Pass
WP000074	Bear Cabin Branch Wetland and Stream Restoration	2018	36.75	5/9/2018	Pass
WP000035	Ring Factory ES SWM Retrofit & Stream Restoration	2018	20.23	7/27/2018	Pass
WP000025	Wheel Creek at Country Walk 1B SWM Retrofit	2017	3.66	6/20/2017	Pass
WP000036	Foster Branch at Dembytown Stream Restoration	2017	21.20	10/3/2018	Pass
WP000024	Wheel Creek at Country Walk 1A SWM Retrofit	2016	8.66	9/21/2017	Pass
WP000026	Wheel Creek at Festival at Bel Air SWM Retrofit	2016	12.00	1/10/2018	Pass
WP000095	Willoughby Beach Road Tree Planting	2016	0.57		
WP000096	Trappe Church Road Tree Planting	2016	0.27		
WP000073	Hickory Elementary Retrofit	2016	0.75	8/16/2017	Pass
WP000031	Norrisville Elementary Bioretention	2015	0.63	1/29/2015	Pass
WP000020	Woodbridge Stream Restoration	2015	12.4	4/5/2018	Pass

WP000051	Amoss Mill Road Tree Planting II	2015	0.21		
WP000052	Edwards Lane Tree Planting II	2015	1.7		
WP000055	Patterson Mill High School Tree Planting II	2015	1.22		
WP000063	Rider Lane Tree Planting	2015	0.76		
WP000064	Oakmont Road Tree Planting	2015	0.44		
WP000093	Red Pump Elementary School Tree Planting II	2015	0.66		
WP000094	Magnolia Middle School Tree Planting II	2015	0.47		
WP000060	Edwards Lane Tree Planting	2015	0.97		
WP000061	Amoss Mill Road Tree Planting	2015	0.18		
WP000062	Harford Christian School Tree Planting	2015	0.62		
WP000032	Foster Branch at Trimble Road Stream Restoration	2014	12.10	7/3/2014	Pass
WP000054	Mt Soma Property Tree Planting	2014	0.97		
WP000056	Magnolia Middle School Tree Planting	2014	0.23		
WP000058	North Harford High School Tree Planting	2014	0.15		
WP000059	Perryman Wellfield Tree Planting	2014	1.81		
WP000019	Woodbridge SWM Retrofit	2014	3.80	11/30/2016	Pass
WP000048	Heaven Waters Boulton Street Tree Planting	2014	0.20		
WP000049	Churchville Recreation Complex Tree Planting	2014	0.24		
WP000050	Walters Mill Tree Planting	2014	1.09		
WP000053	Harford Center Tree Planting	2014	0.22		
WP000022	Wheel Creek at Gardens of Bel Air SWM Retrofit	2014	4.79	12/21/2018	Pass
WP000030	Wheel Creek at Calvert Walks Stream Restoration	2013	7.25	4/8/2013	Pass

WP000057	Patterson Mill High School Tree Planting	2013	0.82		
WP000068	Cedarwood Pump Station Demolition	2013	0.05	N/A	N/A
WP000018	Friends Pond SWM Retrofit	2012	11.70	6/6/2018	Pass
WP000012	Bynum Ridge Stream Stabilization	2012	4.65	5/10/2012	Pass
WP000016	Forest Hill Elementary School Bioretention	2011	0.91	12/21/2018	Pass
WP000017	Hickory Elementary School Bioretention	2011	0.60	8/16/2017	Pass
WP000013	Plumtree Run at Tollgate Stream Restoration	2011	16.80	8/12/2011	Pass
WP000042	Washington Court Demolition	2011	2.11	N/A	N/A
WP000015	Abingdon Library Bioretention	2011	0.60	12/21/2018	Pass



Harford County, MD Department of Public Works
 Watershed Protection and Restoration
 Watershed Restoration Status (MS4 Permit 11-DP-3310)

Active Projects

Project actively under design or construction			
Project design scope of work pending from consultant		Total	355.0

Project	Restoration Type	Complete (FY)	Credits (IA)
Homestead Elementary	Bioretention	2019	3
Tributary to Plumtree Run at Wakefield Manor	Stream Restoration	2019	3
Bynum at St Andrews Way	Stream Restoration	2019	30
Annie's Playground	Stream Restoration, Tree Planting	2019	30
Jarrettsville Elementary	Submerged Gravel Wetland	2019	3
Jarrettsville Shlop	Bioswale	2019	3
Church Creek Elementary	Submerged Gravel Wetland, Stream Restoration	2020	24
Heavenly	Wetland Creation, Stream Restoration	2020	8
Magnolia Middle	Stream Restoration	2020	20
Barrington	Bioretention, RSC, Stormwater Wetland, Stream Restoration	2020	32
Willoughby Beach	Stormwater Wetlands, Stream Restoration	2020	33
Watervale	Stream Restoration	2020	30
Stillmeadow	Stream Restoration	2021	22
Sunnyview	Stream Restoration	2021	30
Northwest Branch Declaration Run	RSC, Stream Restoration	2021	20
Woodland	Stream Restoration	2021	18

C Milton Wright High	Bioretention, Rainwater Harvest, Bioswale, Stream Restoration	2021	35
Lily Run	Stream Restoration	2021	11



Harford County, MD Department of Public Works
 Watershed Protection and Restoration
 Watershed Restoration Status (MS4 Permit 11-DP-3310)

Pending Projects

Total 20.8 \$1,142,350

Project	Restoration Type	Complete (FY)	Credits (IA)	Total
Courthouse (Green Infrastructure Plan)	Bioretention	2020	1.0	\$55,000
Declaration D-ES-15	SWM Retrofit - Bioretention	2020	2.0	\$110,000
Declaration D-NS-13	Green Street Bumpout (Bioretention)	2020	1.0	\$55,000
Declaration D-NS-4	Green Street Bumpout (Bioretention)	2020	2.0	\$110,000
Mariner Point Park (Green Infrastructure Plan)	Tree Planting	2020	1.0	\$55,000
31	SWM Retrofit - Bioretention	2020	1.0	\$55,000
165	SWM Retrofit - Sandfilter	2020	1.7	\$92,950
166	SWM Retrofit - Sandfilter	2020	3.8	\$206,250
167	SWM Retrofit - Sandfilter	2020	3.2	\$174,900
168	SWM Retrofit - Sandfilter	2020	0.9	\$46,750
175	SWM Retrofit - Submerged Gravel Wetland	2020	0.8	\$44,550
191	SWM Retrofit - Sandfilter	2020	2.5	\$136,950



Harford County, MD Department of Public Works
 Watershed Protection and Restoration
 Watershed Restoration Status (MS4 Permit 11-DP-3310)

Identified Projects

Total 1602.7 \$88,148,316

Project	Restoration Type	Complete (FY)	Credits (IA)	Total
Alice & William Longley Park	Tree Planting, Stream Stabilization	TBD	2.0	\$110,000
Flying Point Park	Tree Planting and Bioretention	TBD	1.6	\$87,418
Forest Hill Recreation Complex	Bioretention	TBD	2.0	\$109,655
Harford Glen	Tree Planting and Bioretention	TBD	2.2	\$121,837
Joppatowne HS	Tree planting, stream restoration, bioretention	TBD	20.0	\$1,100,000
North Bend ES	Tree Planting and Bioretention	TBD	2.5	\$138,226
North Harford ES, North Harford MS	Tree Planting and Bioretention	TBD	6.2	\$339,043
Joint project with SCD	Stream Restoration	TBD	20.0	\$1,100,000
Joint project with SCD	Stream Restoration	TBD	20.0	\$1,100,000
Abingdon ES	Bioretention, Stream Restoration	TBD	2.7	\$147,948
Fallston MS, Fallston HS	Tree Planting and Bioretention	TBD	9.9	\$544,592
Aberdeen MS	Tree Planting and Bioretention	TBD	3.4	\$187,186
Bel Air ES	Tree Planting and Bioretention	TBD	1.2	\$66,672
Bus Storage Place	Bioretention	TBD	2.5	\$136,711

Churchville Recreation Complex	Tree Planting and Bioretention	TBD	2.5	\$134,780
Dublin ES	Tree Planting and Bioretention	TBD	1.4	\$76,417
Edgeley Grove Farm	Tree Planting and Bioretention	TBD	3.0	\$165,170
Edgewater Village Park	Tree Planting	TBD	0.5	\$25,105
Edgewood ES	Tree Planting and Bioretention	TBD	3.1	\$171,979
Fallston Library	Tree Planting	TBD	0.7	\$39,117
Forest Lakes ES	Tree Planting and Bioretention	TBD	2.4	\$131,387
Fountain Green ES	Tree Planting	TBD	3.0	\$162,556
George D.Lisby ES at Hillsdale	Tree Planting and Bioretention	TBD	1.7	\$95,021
Halls Cross Road ES	Tree Planting and Bioretention	TBD	2.0	\$112,739
Harford County Detention Center	Bioretention	TBD	2.3	\$128,652
Havre de Grace ES	Bioretention, Stream Restoration	TBD	1.5	\$84,873
Hickory ES	Tree Planting and Bioretention	TBD	4.3	\$236,172
Jarrettsville Library	Bioretention	TBD	1.7	\$96,123
John Archer Sp Ed, Prospect Mill ES, Harford Technical HS	Tree Planting and Bioretention	TBD	10.3	\$566,529
Joppatowne ES	Tree Planting and Bioretention	TBD	2.4	\$132,479
North Harford HS	Bioretention, Stream/Wetland Restoration	TBD	6.7	\$367,417
Patterson MS, Patterson HS	Tree Planting	TBD	8.4	\$460,300
Riverside ES	Tree Planting and Bioretention	TBD	1.7	\$94,555
Roye-Williams ES	Tree Planting and Bioretention	TBD	2.1	\$118,159
Southampton MS	Tree Planting and Bioretention	TBD	3.0	\$167,141
Swan Harbor Farm	Tree Planting	TBD	3.8	\$208,759

Whiteford Library	Tree Planting and Bioretention	TBD	0.4	\$20,088
William S.James ES	Tree Planting and Bioretention	TBD	1.7	\$95,613
Aldino Rd County Property	Tree Planting	TBD	7.5	\$411,950
Darlington Rt1 Park-and-Ride	Tree Planting	TBD	2.4	\$131,450
Dublin County Property A	Tree Planting	TBD	3.8	\$209,000
Dublin County Property B	Tree Planting	TBD	0.8	\$46,200
Dublin County Property C	Tree Planting	TBD	4.5	\$248,600
Dublin County Property D	Tree Planting	TBD	3.9	\$215,050
Eden Mill Big Branch	Tree Planting	TBD	0.8	\$44,000
Eden Mill Hilltop	Tree Planting	TBD	1.1	\$62,700
Norrisville Rec	Tree Planting	TBD	11.7	\$643,500
OS1	Step Pool Stormwater Conveyance	TBD	1.9	\$106,150
OS2	Step Pool Stormwater Conveyance	TBD	1.0	\$52,250
R1	SWM Retrofit - Stormwater Wetland	TBD	2.1	\$115,500
R2	SWM Retrofit - Stormwater Wetland	TBD	2.4	\$134,200
R3	SWM Retrofit - Stormwater Wetland	TBD	6.4	\$350,350
R4	SWM Retrofit - Stormwater Wetland	TBD	4.6	\$255,200
R5	SWM Retrofit - Stormwater Wetland	TBD	6.1	\$335,500
Rt1 Re-Planting	Tree Planting	TBD	1.8	\$98,450
Sandy Hook	Tree Planting	TBD	11.6	\$637,450
Sandy Hook UT	Stream Restoration	TBD	4.5	\$247,500
Scarboro	Tree Planting	TBD	7.0	\$382,250

ST1	Stream Restoration	TBD	20.5	\$1,127,500
ST2	Stream Restoration	TBD	4.5	\$247,500
ST3	Stream Restoration	TBD	48.0	\$2,637,250
ST4	Stream Restoration	TBD	5.5	\$302,500
ST5	Stream Restoration	TBD	12.0	\$660,000
ST6	Stream Restoration	TBD	7.0	\$385,000
Thomas Run A	Stream Restoration	TBD	18.5	\$1,017,500
Thomas Run B	Stream Restoration	TBD	49.2	\$2,706,000
Walters Mill	Tree Planting	TBD	1.0	\$56,650
Walters Mill UT	Stream Restoration	TBD	7.6	\$415,250
WR1	Wetland Restoration	TBD	1.0	\$55,000
WR2	Wetland Restoration	TBD	1.0	\$55,000
SR-10	Stream Restoration	TBD	18.7	\$1,028,500
SR-2	Stream Restoration	TBD	12.5	\$687,500
SR-3	Stream Restoration	TBD	51.6	\$2,838,000
SR-4	Stream Restoration	TBD	23.8	\$1,309,000
SR-5	Stream Restoration	TBD	12.0	\$660,000
SR-6	Stream Restoration	TBD	9.5	\$522,500
SR-8	Stream Restoration	TBD	18.7	\$1,028,500
SR-9	Stream Restoration	TBD	12.7	\$698,500
SWM-1	SWM Retrofit - Stormwater Wetland	TBD	15.4	\$847,000
SWM-2	SWM Retrofit - Stormwater Wetland	TBD	22.7	\$1,248,500

SWM-3	SWM Retrofit - Sandfilter	TBD	6.0	\$330,000
SWM-4	Step Pool Stormwater Conveyance	TBD	7.0	\$385,000
SWM-5	Step Pool Stormwater Conveyance	TBD	2.1	\$115,500
Fairmont	Stream Restoration	TBD	15.0	\$825,000
Macphail, Brosvenor, Brook Hill	Stream Restoration and Outfall Stabilization	TBD	55.0	\$3,025,000
Ring Factory	Stream Restoration	TBD	22.0	\$1,210,000
Victory	Stream Restoration and Outfall Stabilization	TBD	26.0	\$1,430,000
SR 1-4 & SR 1-3 & SR 1-2	Stream Restoration	TBD	8.0	\$440,000
SR 3-1 & SR 3-2	Stream Restoration	TBD	4.0	\$220,000
SR 6-1	Stream Restoration	TBD	8.0	\$440,000
SR 7-1 & SR 8-1	Stream Restoration	TBD	19.0	\$1,045,000
6	Stream Restoration	TBD	19.0	\$1,045,000
9	Stream Restoration	TBD	14.0	\$770,000
1b	Stream Restoration	TBD	12.0	\$660,000
3a	Stream Restoration	TBD	18.0	\$990,000
7 & 5b	Stream Restoration	TBD	23.0	\$1,265,000
SR-1	Stream Restoration	TBD	51.3	\$2,821,500
Declaration - D-ES-2	WQ Trap Retrofit - Stormwater Wetland	TBD	5.0	\$275,000
Declaration - Reach 2	Outfall Stabilization	TBD	4.0	\$220,000
Declaration D-ES-12	SWM Retrofit - Stormwater Wetland	TBD	1.0	\$55,000
Declaration D-ES-6	WQ Trap Retrofit - Bioretention	TBD	2.0	\$110,000
Declaration -D-ES-7	Bioswale and Bioretention	TBD	2.0	\$110,000

Declaration D-NS-7	Step Pool Stormwater Conveyance	TBD	2.0	\$110,000
Riverside - R-ES-1	SWM Retrofit - Stormwater Wetland	TBD	40.0	\$2,200,000
Riverside - R-NS-1	Bioretention	TBD	2.0	\$110,000
Riverside - R-NS-5	Tree Planting	TBD	1.0	\$55,000
Riverside - R-NS-7&8	Bioswale	TBD	4.0	\$220,000
SR-1	Stream Restoration	TBD	18.4	\$1,012,000
SR-2	Stream Restoration	TBD	18.4	\$1,012,000
SR-3	Stream Restoration	TBD	5.0	\$275,000
SR-4	Stream Restoration	TBD	20.5	\$1,127,500
SR-5	Stream Restoration	TBD	24.7	\$1,358,500
SWM-1	Sand Filter	TBD	13.2	\$726,000
SWM-2	SWM Retrofit - Submerged Gravel Wetland	TBD	1.9	\$104,500
SWM-3	Submerged Gravel Wetland	TBD	1.9	\$104,500
SWM-4	SWM Retrofit - Stormwater Wetland	TBD	2.5	\$137,500
SWM-5	Bioretention	TBD	1.9	\$104,500
SWM-6	SWM Retrofit - Stormwater Wetland	TBD	1.2	\$66,000
SWM-7	SWM Retrofit - Stormwater Wetland	TBD	0.9	\$49,500
23	SWM Retrofit - Bioretention	TBD	0.3	\$18,700
33	SWM Retrofit to Stormwater Wetland	TBD	7.4	\$405,350
34	SWM Retrofit - Bioretention	TBD	0.5	\$25,300
35	SWM Retrofit - Bioretention	TBD	0.9	\$49,500
38	SWM Retrofit - Stormwater Wetland	TBD	0.4	\$21,450

52	Bioretention	TBD	1.4	\$78,650
112	SWM Retrofit - Stormwater Wetland	TBD	1.6	\$90,200
113	SWM Retrofit - Stormwater Wetland	TBD	2.5	\$135,850
114	SWM Retrofit - Stormwater Wetland	TBD	6.2	\$339,900
144	SWM Retrofit - Stormwater Wetland	TBD	7.9	\$433,950
145	SWM Retrofit - Stormwater Wetland	TBD	6.7	\$366,300
156	SWM Retrofit - Bioretention	TBD	1.2	\$63,800
157	SWM Retrofit - Bioretention	TBD	2.6	\$145,200
158	SWM Retrofit - Stormwater Wetland	TBD	1.0	\$52,800
159	SWM Retrofit - Bioretention	TBD	1.2	\$68,200
162	SWM Retrofit - Stormwater Wetland	TBD	1.1	\$59,950
163	SWM Retrofit - Stormwater Wetland	TBD	4.8	\$262,900
164	SWM Retrofit - Stormwater Wetland	TBD	1.3	\$69,850
169	SWM Retrofit - Stormwater Wetland	TBD	4.1	\$227,700
170	SWM Retrofit - Stormwater Wetland	TBD	12.9	\$709,500
171	SWM Retrofit - Stormwater Wetland	TBD	14.8	\$812,900
172	SWM Retrofit - Bioretention	TBD	5.2	\$285,450
173	SWM Retrofit - Stormwater Wetland	TBD	6.6	\$364,650
174	SWM Retrofit - Submerged Gravel Wetland	TBD	0.4	\$19,800
176	SWM Retrofit - Stormwater Wetland	TBD	4.4	\$243,100
179	SWM Retrofit - Stormwater Wetland	TBD	7.6	\$420,200
180	SWM Retrofit - Sandfilter	TBD	1.8	\$97,900

181	SWM Retrofit - Stormwater Wetland	TBD	1.4	\$74,800
184	SWM Retrofit - Stormwater Wetland	TBD	14.0	\$767,250
190	SWM Retrofit - Stormwater Wetland	TBD	1.5	\$84,700
194	SWM Retrofit - Bioretention	TBD	0.9	\$51,150
195	SWM Retrofit - Bioretention	TBD	0.1	\$6,050
202	SWM Retrofit - Stormwater Wetland	TBD	1.9	\$106,700
Bynum Run@ Blake's Venture Park	Stream Restoration	TBD	25.0	\$1,375,000
Bynum Run@ Harford Detention Center	Stream Restoration	TBD	8.0	\$440,000
Bynum Run@ MD-23	Stream Restoration	TBD	21.0	\$1,155,000
Bynum Run@ Moores Mill Road	Stream Restoration	TBD	23.0	\$1,265,000
Bynum Run@ Newport Drive	Stream Restoration	TBD	5.0	\$275,000
N101	Bioretention	TBD	0.5	\$25,300
N102	Bioswale	TBD	4.2	\$228,250
N103	Stormwater Wetland	TBD	2.0	\$107,800
N104	Stormwater Wetland	TBD	3.9	\$216,700
N105	Bioretention	TBD	1.0	\$56,100
N106	Stormwater Wetland	TBD	1.0	\$56,100
N107	Bioswale	TBD	1.9	\$104,500
N108	Stormwater Wetland	TBD	7.3	\$403,700
N109	Bioswale	TBD	0.8	\$42,900
N110	Step Pool Stormwater Conveyance	TBD	4.8	\$261,250
N112	Bioretention	TBD	0.4	\$21,450

N113	Bioswale	TBD	1.2	\$67,650
N114	Bioswale	TBD	1.8	\$100,650
N115	Bioretention	TBD	1.3	\$68,750
N116	Bioretention	TBD	0.9	\$48,400
N117	Bioretention	TBD	1.2	\$64,900
N118	Stormwater Wetland	TBD	23.3	\$1,278,750
N119	Bioretention	TBD	0.2	\$11,550
N120	Stormwater Wetland	TBD	1.7	\$91,300
N121	Stormwater Wetland	TBD	3.6	\$199,100
N123	Bioretention	TBD	3.0	\$164,450
N124	Stormwater Wetland	TBD	3.9	\$216,700
N125	Stormwater Wetland	TBD	7.4	\$405,350
N126	Stormwater Wetland	TBD	1.8	\$101,200
N127	Stormwater Wetland	TBD	6.1	\$337,700
N128	Bioretention	TBD	0.5	\$29,150
N129	Stormwater Wetland	TBD	1.8	\$97,900
N130	Bioretention	TBD	0.9	\$49,500
N131	Stormwater Wetland	TBD	4.1	\$226,050
N132	Bioretention	TBD	1.4	\$77,000
N137	Stormwater Wetland	TBD	3.5	\$193,600
N138	Bioretention	TBD	0.9	\$47,850
N141	Bioretention	TBD	0.3	\$18,150

N142	Bioretention	TBD	0.5	\$29,700
N143	Bioretention	TBD	1.0	\$53,900
Unnamed Tributary@ Switchman Drive	Stream Restoration	TBD	4.0	\$220,000
Unnamed Tributary@ MD 543	Stream Restoration	TBD	37.0	\$2,035,000
Unnamed Tributary@ Bel Air Bypass	Stream Restoration	TBD	23.0	\$1,265,000
Unnamed Tributary@ Broadway	Stream Restoration	TBD	23.0	\$1,265,000
Unnamed Tributary@ Centreville Way	Stream Restoration	TBD	20.0	\$1,100,000
Unnamed Tributary@ Frog Leap Way	Stream Restoration	TBD	8.0	\$440,000
Unnamed Tributary@ MD-22	Stream Restoration	TBD	12.0	\$660,000
Unnamed Tributary@ Melrose Lane	Stream Restoration	TBD	22.0	\$1,210,000
Unnamed Tributary@ Piper Cove Way	Stream Restoration	TBD	11.0	\$605,000
Unnamed Tributary@ Rockfield Park	Stream Restoration	TBD	25.0	\$1,375,000

Watershed Assessment	Credits (IA)
County-owned properties	126.9
Deer Creek (2018)	261.7
Emmord Branch (2018)	264.0
Taylor's Creek (2018)	110.5
Upper Bynum Run (2018)	493.6
Farnandis Branch (2017)	118.0
Declaration Run / Riverside Area (2014)	63.0
Foster Branch (2012)	39.0

Plumtree Run (2011)	86.0
Other	40.0
Total	1,602.7

Watershed Restoration Project Monitoring - Woodbridge

Woodbridge Year 1 Post-construction Monitoring



Pre-construction



Post-construction

Prepared for:
The Harford County
Department of Public
Works

December 20, 2016

Prepared by:
KCI Technologies Inc.
936 Ridgebrook Road
Sparks, MD
21152

KCI Job Number:
17134556.03



Table of Contents

1.	INTRODUCTION	1
1.1.	<i>Restoration Design Description</i>	<i>1</i>
1.1.	<i>Monitoring Schedule.....</i>	<i>3</i>
1.2.	<i>Riparian Planting Inspection.....</i>	<i>3</i>
1.3.	<i>Geomorphic Assessment.....</i>	<i>3</i>
1.3.1.	<i>Cross-sectional Surveys and Longitudinal Profile Survey.....</i>	<i>5</i>
1.3.2.	<i>Radius of Curvature Survey.....</i>	<i>5</i>
1.3.3.	<i>Bed and Bank Stability.....</i>	<i>5</i>
1.3.4.	<i>Evaluation of Channel and Bank Stabilization Structures.....</i>	<i>6</i>
1.4.	<i>Physical Habitat Evaluation.....</i>	<i>6</i>
1.5.	<i>Biological Monitoring</i>	<i>7</i>
2.	MONITORING YEAR 1: RESULTS AND DISCUSSION	8
2.1.	<i>Riparian Planting Inspection.....</i>	<i>8</i>
2.2.	<i>Geomorphic Assessment.....</i>	<i>10</i>
2.2.1.	<i>Cross-sectional Surveys.....</i>	<i>10</i>
2.2.2.	<i>Longitudinal Profile Survey.....</i>	<i>10</i>
2.2.3.	<i>Radius of Curvature Survey.....</i>	<i>11</i>
2.2.4.	<i>Bed and Bank Stability.....</i>	<i>11</i>
2.2.5.	<i>Evaluation of Channel and Bank Stabilization Structures.....</i>	<i>12</i>
2.3.	<i>Physical Habitat Evaluation.....</i>	<i>13</i>
2.4.	<i>Biological Monitoring</i>	<i>14</i>
3.	CONCLUSIONS.....	17
4.	REFERENCES	18

Figures

Figure 1.	Vicinity Map	2
Figure 2.	Site Assessment Location Map	4
Figure 3.	Comparison with Pre-Construction (2005-2007) PHI Scores.....	14
Figure 4.	Comparison with Pre-Construction (2005-2007) BIBI Scores	16
Figure 5.	Comparison of BIBI Scores at the MBSS Reference Site (2009-2015)	17

Tables

Table 1.	RBP Low Gradient Habitat Parameters.....	7
Table 2.	RBP Habitat Score and Ratings.....	7
Table 3.	PHI Coastal Plain Parameters.....	7
Table 4.	PHI Score and Ratings	7
Table 5.	Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates.....	8
Table 6.	BIBI Scoring and Rating	8
Table 7.	Cross-sectional Analysis Statistics	10
Table 8.	Longitudinal Profile Slope Comparison.....	11
Table 9.	Radius of Curvature Results.....	11
Table 10.	Pebble Count Material.....	12
Table 11.	Physical Habitat Assessment Results 2015	13
Table 12.	Benthic Index of Biotic Integrity (BIBI) Summary Data 2016.....	15
Table 13.	MBSS Reference Site Benthic Index of Biotic Integrity (BIBI) Summary Data 2016.	15

Appendices

Appendix A. Site Photographs

A-1. Vegetative Assessment Photographs

A-2. Geomorphic Assessment Photographs

A-3. Structure Assessment Photographs

Appendix B. Cross Section Survey Data

Appendix C. Longitudinal Profile Survey Data

Appendix D. Pebble Count Data

Appendix E. Physical Habitat Data

Appendix F. Biological Assessment Data

1. INTRODUCTION

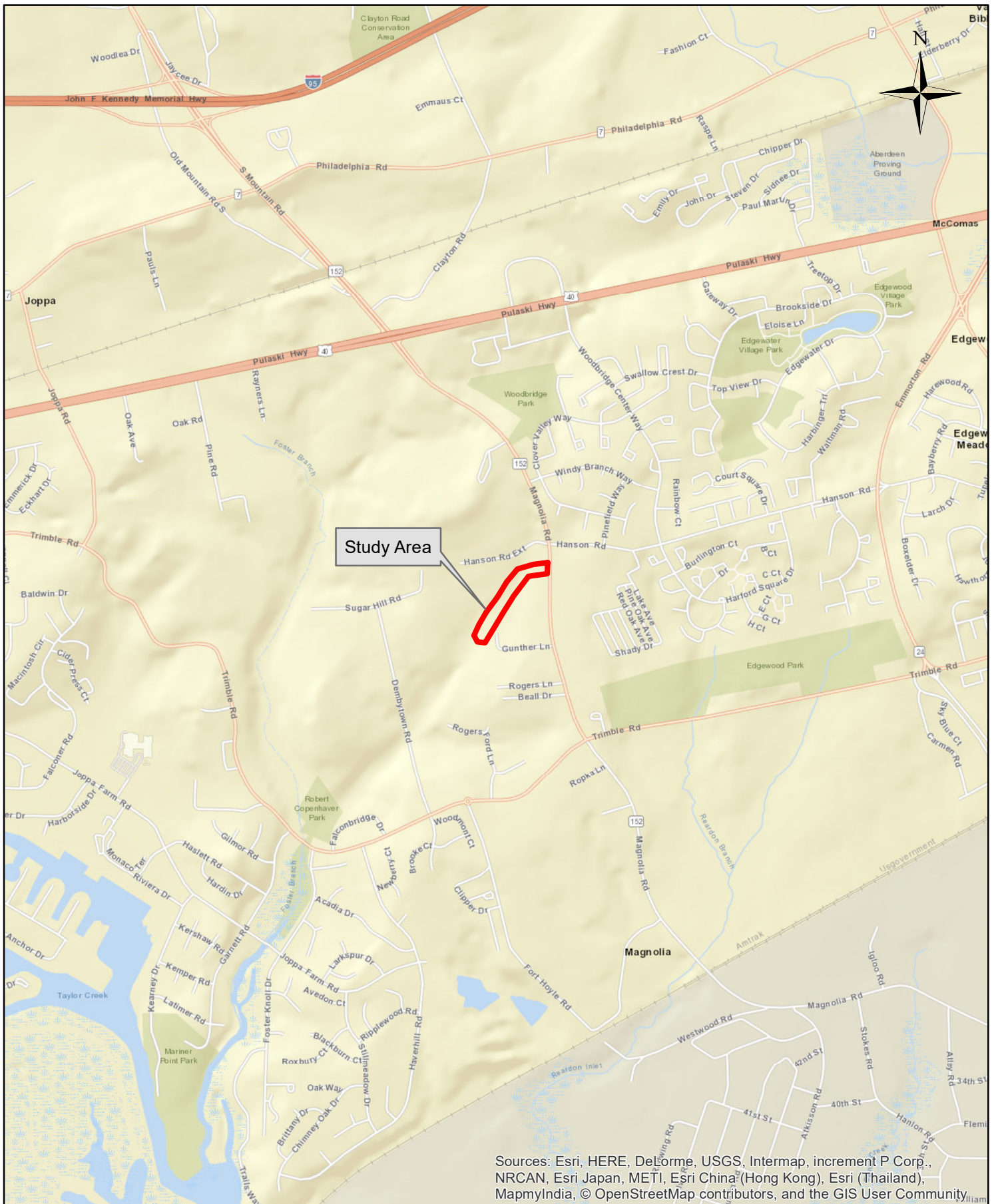
This report documents the first year of a three-year post-construction monitoring study for the stream restoration of an unnamed tributary to Foster Branch at Woodbridge. The project area is located in Joppatowne in southern Harford County, Maryland, and is situated southwest of the intersection of Magnolia Road (MD 152) and Hanson Road (see Figure 1, Project Vicinity Map).

Post-construction monitoring includes geomorphic, physical habitat, riparian buffer planting, biological assessments, and structure inspections. The Harford County Department of Public Works requested these services from KCI Technologies, Inc. (KCI) in order to assist with documenting the success of the restoration project that was completed in April 2015. Stream restoration monitoring will be conducted annually for three years, with assessments being completed in 2016 through 2018. The Year 1 geomorphic and biological monitoring surveys were conducted in April 2016, with a vegetation assessment completed in August 2016.

The main purpose of this study is to document and analyze the current and future stability of the restoration project and to support the County in its efforts to comply with the Woodbridge Stream Restoration Joint Permit (permit # 2011-60634-M24). Future yearly monitoring evaluations will supplement this data. Photographs of the site were taken and are included in Appendix A.

1.1. Restoration Design Description

The Woodbridge Stream Restoration project is 1,250 linear feet (LF) of stream restoration with a variety of stream stabilizing structures. The upstream portion of the project prior to restoration was highly degraded with 10-12 foot high banks. Private property adjacent to the extents of channel erosion made avoidance of impacts a challenge to design. The result is the Stepped Riffle Complex system that retains up to the 10-year discharge within the channel and drops over a steep gradient in a controlled manner for approximately 300 LF. The middle segment was several tortuous meanders that had too tight of radius of curvature, mature trees along both banks, and private property. Restoration in this segment consisted of 550 LF of riffle-pool sequence that was stabilized with riffle grade controls and stone toe protection. The last 30 LF consisted of a set of three step pools to bring the channel down to the elevation of the driveway culverts dictating channel elevation. The lower segment begins downstream of the culvert and contains 400 LF of minimal restoration efforts. The site conditions at the time of assessment and the general wish of the private property owner who owns the property was to leave the channel bed and left bank undisturbed during restoration after the immediate grade control downstream of the culvert. Only bank grading and stabilization with natural fiber matting and live stakes was to be conducted on the right bank for approximately 350 LF. At the end of this distance a stone sill was placed to mitigate any downstream disturbance from migrating up into the restoration area.



Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

**Woodbridge Stream Restoration
Post-Construction Monitoring
Figure 1. Vicinity Map
Harford County, Maryland
KCI Job No. 17134556.03**

0 1,000 2,000 4,000
Feet
1" = 2000'

Legend

Study Area

METHODOLOGY

1.1. Monitoring Schedule

The Woodbridge site is being assessed annually for a period of three years around the same time each year. Data collected during Year 1 (2016) monitoring efforts shall serve as the baseline data to which future monitoring events will be compared. The monitoring assessment includes evaluations of riparian plantings, geomorphic assessments, physical habitat evaluation, biological monitoring, and structure inspections. Geomorphic and biological assessment locations can be seen in Figure 2, Site Assessment Location Map. Photographic documentation was collected during assessments for comparison of observations and can be referenced in Appendix A.

Stationing described in this report was coordinated with the design plan baseline, running from upstream to downstream, and will be referred to as the survey station. All assessments of bank and vegetation are approximate to the survey stationing. Right and left banks are designated facing downstream.

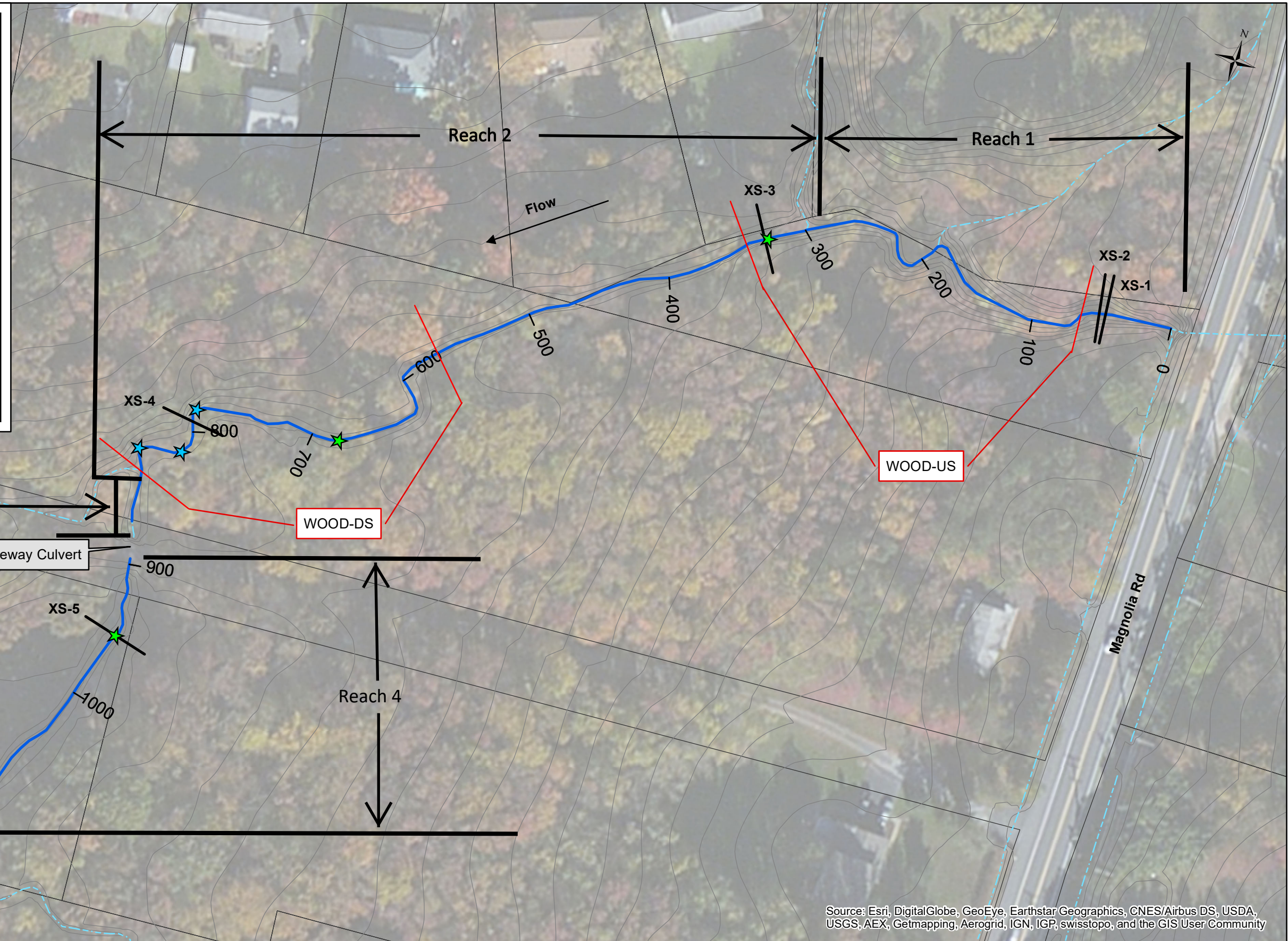
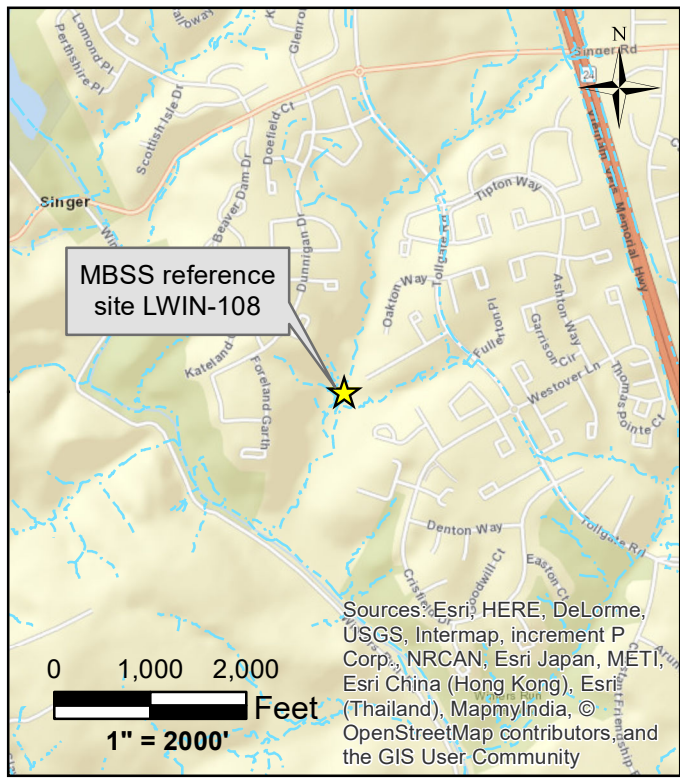
1.2. Riparian Planting Inspection

An inspection of riparian buffer plantings was completed to assess the establishment and survivability of riparian buffer plantings. Each planting zone was assessed according to the planting zones noted on the landscape plans. The planting zones were designed as either turf grass, reforestation, or live stake zones. Each planting zone was qualitatively assessed for overall health, survival, and establishment. Additionally, the planting zones were inspected to identify evidence of invasive species, infestation, disease, browsing, mortality, and the establishment of volunteer species. The percentage of survivability of live stakes on the stream banks was visually estimated. Survivability is defined as evidence of growth leading to the development of healthy leaves and roots.

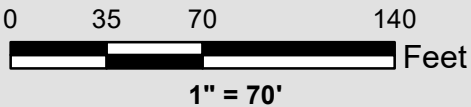
During the above inspections, associated notes and photo documentation were taken to assess the overall functionality of vegetation along the stream banks. Functionality is defined as evidence of root growth that is maintaining the integrity of the stream bank. Areas where vegetative establishment within the project limits is sparse or non-existent may become prone to erosion. The photographic documentation is included in Appendix A-1.

1.3. Geomorphic Assessment

Geomorphic assessments include a longitudinal profile survey for the entire project length, 5 cross-sectional surveys, radius of curvature measurements, evaluation of sediment characteristics, and inspection of structures. The field procedures used for the geomorphic assessments were adapted from *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (Harrelson et al, 1994). Geomorphic assessments were completed to quantify basic stream characteristics including bed and bank stability as well as transport and deposition of bed materials. Cross-sectional and longitudinal profile surveys were conducted to compare future changes in the channel's hydraulic geometry over the course of the monitoring years. Photographic documentation is included in Appendix A-2.



Woodbridge Stream Restoration
Post-Construction Monitoring
Figure 2. Site Assessment Location Map
Harford County, Maryland
KCI Job No. 17134556.03



Legend

- | | | | |
|-----------------|------------------------------|----------------------------------|-------------|
| Restored Stream | Pebble Count Location | Cross Section | 2' Contours |
| Other Streams | Radius of Curvature Location | Biological Sampling Reach Limits | Parcels |

1.3.1. Cross-sectional Surveys and Longitudinal Profile Survey

Prior to beginning monitoring, five (5) permanent monumented cross sections were installed at locations along the study reach. Each monument consists of a 2 foot long rebar placed vertically into the ground and marked with a yellow cap, emblazed with “KCI NRM”. In addition to these sections, a profile for the mainstem was established and surveyed. The 0+00 point is the culvert invert at the upstream extent of the project. The location of the channel and associated cross sections can be seen in Figure 2 Assessment Location Map.

Each cross section’s elevation provided was tied to the pipe invert at the upstream start of the project site. Survey elevations of all cross sections were recorded at two-foot horizontal intervals outside the top of bank points and at one-foot horizontal intervals between the top of bank points. Cross-sectional data were plotted and analyzed for bankfull width, mean depth, width/depth ratio, cross-sectional area, and discharge. Future cross-sectional data will be overlaid with this baseline data for comparison purposes.

The low top of bank elevations identified in the field surveys were near to the designed bankfull elevations and were therefore designated as the bankfull elevations at the five corresponding cross sections to be monitored. These bankfull elevations are used to calculate each cross section’s statistics, and will be used as permanent reference points from which to note future changes in cross-sectional geometry. The cross-sectional statistics were derived from a KCI developed Excel spreadsheet (KCI 2013) with calculations based on the Reference Reach spreadsheet (Mecklenburg 2006).

The longitudinal profile of the stream was surveyed to document constructed instream bed features that will aid in assessing the overall success of restoration at the site. The profile was established along the thalweg and included facet slopes, the water surface, and prominent features (e.g. crests, pools, riffles) where notable. Longitudinal profile data were used to calculate channel slope and document the current positioning of these bed features. Profile data was also analyzed and presented using the KCI (2013) spreadsheet.

1.3.2. Radius of Curvature Survey

The radius of curvature is a measurement utilized to evaluate channel resistance to erosion and bend or meander migration rates (Rosgen 1996). The radius of curvature was measured at three (3) meander bends between design stations 5+00 and 8+50 to track potential lateral channel migration. Radius of curvature measurements are taken via the cord length method (Leopold *et al.* 2000). The following locations are at the approximate center of each meander:

- Station 5+50
- Station 6+25
- Station 7+75

1.3.3. Bed and Bank Stability

The stability of the bed and banks are assessed in a variety of ways. Data from the cross sections, longitudinal and bank profiles and pebble counts will be used to look at changes over time.

A bank profile survey was conducted at three locations. The bank profile survey will be used instead of bank survey pins. This was determined to be the best method since there is gravel and cobble within the banks which is considered material unsuitable for bank pin evaluations due to disturbance during installation (Rosgen 2006). Additionally, bank pins were not installed since each bank is reinforced with stone toe protection making installation of bank pins infeasible. Channel-ward of the stone toe, bed pins

were able to be installed and consisted of a 2 feet long rebar with yellow survey cap. Bank profiles will be replicated each year based on the measurement heights established in the Year 1 survey. The bank profiles were measured at the following locations:

- Station 3+55
- Station 6+54.5
- Station 8+09

Three (3) riffle pebble counts were conducted following standard methods by Wolman (1954) using the 100-count assessment. Pebble counts were taken at the following locations, shown in Figure 2:

- Station 3+28 (cross section 3)
- Station 6+88
- Station 9+53 (cross section 5)

1.3.4. Evaluation of Channel and Bank Stabilization Structures

A visual assessment of the Stepped Riffle Complex (SRC) structure, riffle grade control, stone sill, cascade crest, and stone toe protection was completed to evaluate the success of these stabilization structures. The assessment focused on observed structural integrity of the stabilization techniques noting evidence of deterioration, dislodgement, etc. Typical areas of concern include locations where shifting, scouring, and undercutting compromises the stability of the structures. In addition, the function and performance of each structure within the restoration reach was qualitatively assessed. This assessment can be used to pinpoint the areas of concern and recommend appropriate remedial actions as necessary. Photographic documentation of these areas is included in Appendix A-3.

1.4. Physical Habitat Evaluation

Physical habitat was evaluated at two (2) biological monitoring sites (see Figure 2). The biological monitoring sites were characterized based on visual observations of physical characteristics and various habitat parameters. The EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for low gradient streams (Barbour et al., 1999) and the Maryland Biological Stream Survey's (MBSS) Physical Habitat Index (PHI; Paul et al., 2003) were used to assess the physical habitat at each site. Both assessment techniques rely on subjective scoring of selected habitat parameters. To reduce individual sampler bias, both assessments were completed as a team with discussion and agreement of the scoring for each parameter. In addition to the visual assessments, photographs were taken from three locations within each sampling reach (downstream end, mid-point, and upstream end) facing in the upstream and downstream direction, for a total of six (6) photographs per site (Appendix A-4).

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health (Table 1). Each parameter is given a numerical score from 0-20 (20 = best, 0 = worst), or 0-10 for individual bank parameters (i.e., bank stability, vegetative protection, and riparian vegetative zone width), and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases.

Table 1. RBP Low Gradient Habitat Parameters

Low Gradient Stream Parameters	
Epifaunal substrate/available cover	Channel alteration
Pool substrate characterization	Channel sinuosity
Pool variability	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian Vegetative Zone Width

The RBP habitat parameters for each reach are summed, with a total possible score of 200. The total score is then placed into one of four narrative categories (Table 2) based on the percent comparability to reference conditions.

Table 2. RBP Habitat Score and Ratings

Score	Percent of Reference	Narrative Rating
≥180	≥90%	Comparable to Reference
150-179	75% - 89%	Supporting
120-149	60% - 74%	Partially Supporting
≤119	≤60%	Non-Supporting

The PHI incorporates the results of a series of habitat parameters selected for Coastal Plain, Piedmont and Highlands regions. While all parameters are rated during the field assessment, the Coastal Plain parameters are used to develop the PHI score. In developing the PHI, MBSS identified six parameters that have the most discriminatory power for coastal plain streams. These parameters are used in calculating the PHI (Table 3). Several of the parameters have been found to be drainage area dependent and are scaled accordingly.

Table 3. PHI Coastal Plain Parameters

Coastal Plain Stream Parameters	
Remoteness	Instream Habitat
Shading	Woody Debris and Rootwads
Epibenthic Substrate	Bank Stability

Each habitat parameter is given an assessment score ranging from 0-20, with the exception of shading (percentage) and woody debris and rootwads (total count). A prepared score and scaled score (0-100) are then calculated. The average of these scores yields the final PHI score. The final scores are then ranked according to the ranges shown in Table 4 and assigned corresponding narrative ratings, which allows for a score that can be compared to habitat assessments performed statewide.

Table 4. PHI Score and Ratings

PHI Score	Narrative Rating
81.0 – 100.0	Minimally Degraded
66.0 – 80.9	Partially Degraded
51.0 – 65.9	Degraded
0.0 – 50.9	Severely Degraded

1.5. Biological Monitoring

Benthic macroinvertebrate sampling was conducted at the two established biological monitoring sites: Wood-US and Wood-DS (see Figure 2). Samples were collected following MBSS protocols (MDNR, 2014) by field personnel certified by MDNR in MBSS sample collection procedures. Benthic

macroinvertebrate samples were processed and identified according to methods described in *MBSS Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy* (Boward and Friedman, 2000) by Environmental Services & Consulting, LLC. Identification of the specimens is conducted to the genus level for most organisms. Groups including Oligochaeta and Nematomorpha were identified to the family level while Nematoda was left at the phylum. Individuals of early instars or those that may be damaged are identified to the lowest possible level, which could be phylum or order but in most cases would be family.

Benthic macroinvertebrate data were analyzed using methods developed by MBSS as outlined in the *New Biological Indicators to Better Assess the Condition of Maryland Streams* (Southerland et al., 2005). The Benthic Index of Biotic Integrity (BIBI) approach involves statistical analysis using metrics that have a predictable response to water quality and/or habitat impairment. The metrics selected fall into five major groups including taxa richness, composition measures, tolerance to perturbation, trophic classification, and habit measures. The current study area is located within the coastal plain physiographic region; therefore, the coastal plain BIBI was calculated for data analysis. Raw values from each metric are given a score of 1, 3 or 5 based on ranges of values developed for each metric as shown in Table 5. The results are combined into a scaled BIBI score ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned (Table 6).

Table 5. Biological Condition Scoring for the Coastal Plain Benthic Macroinvertebrates

Metric	Score		
	5	3	1
Total Number of Taxa	≥22	14-21	<14
Number of EPT Taxa	≥5	2-4	<2
Number of Ephemeroptera Taxa	≥2.0	1-1	<1.0
Percent Intolerant Urban Taxa	≥28	10-27	<10.0
Percent Ephemeroptera Taxa	≥11	0.8-10.9	<0.8
Number Scraper Taxa	≥2	1-1	<1.0
Percent Climber Taxa	≥8.0	0.9-7.9	<0.9

Table 6. BIBI Scoring and Rating

BIBI Score	Narrative Rating
4.0 – 5.0	Good
3.0 – 3.9	Fair
2.0 – 2.9	Poor
1.0 – 1.9	Very Poor

2. MONITORING YEAR 1: RESULTS AND DISCUSSION

2.1. Riparian Planting Inspection

An inspection of the riparian buffer plantings at the site was completed on August 4, 2016. The majority of surviving plants appear healthy and free of insects and diseases. Photo documentation of the bank and riparian buffer planting inspections is presented in Appendix A-1.

Live Stake Zone

In general, the live stake bank plantings showed vigorous growth and were very healthy. The bank plantings included four species of live stakes (gray dogwood, silky dogwood, black willow, and streamco willow). Typically dogwood species (*Cornus* sp.) are much slower growing than willow species (*Salix* sp.), however all species were equally vigorous throughout the site. Japanese beetles were noted on the willow live stakes, but did not appear to be causing significant damage to the plants at the time of the inspection. Average survival ranged from 90-100% throughout the site. However, one location had extremely poor survival at less than 10% between station 9+50 to 10+00. Survival is low as a result of the bank erosion on the right bank. Many stakes have fallen from the bank.

Live stakes were substituted for the live branch layers specified on the landscape plans and assessment of these live stakes were included in the overall live stake zone assessment.

Reforestation Zone

The trees and shrubs of the reforestation zone had excellent survival and vigor. The overall survival of trees was estimated at 99% and shrub survival was estimated at 95%. All tree species were healthy, however American sycamore, tulip poplar, and river birch were found to be the most vigorous species. All tree shelters were in place and effective. Spicebush shrubs were the most vigorous of the shrub species. Some insect herbivory was observed on the arrowwood viburnum, however it is expected that the shrubs will survive.

Some minor dieback was observed in the existing mature trees, particularly at the upstream end of the site, likely as a result of construction stressors. These trees should be monitored carefully and removed if necessary to avoid uprooting and bank instability.

Many volunteer seedlings were observed in the reforestation zone, including sweet gum and tulip poplar trees.

Turf Grass and Permanent Seeding Zones

Two turf grass zones were established in lawns adjacent to the stream. Overall, turf grass coverage was 93%. Turf grass zones were being maintained by the homeowners.

Permanent seeding was established throughout the live stake and reforestation zones. Overall coverage was estimated 85%. Poor establishment was noted from stations 0+00 to 2+25, where bare areas of gravel and sediment were found. This poor establishment may be a result of road runoff from Magnolia Road. Downstream from the tributary on the right bank at station 2+25, average coverage is 96%. Switchgrass, deertongue grass, and fringed brome were the most vigorous of the planted species. Many volunteer species were found in the herbaceous layer of the reforestation zone, including sedges, rushes, and hay-scented fern. Jewelweed and beggarticks were found robustly growing in the channel throughout the site.

Invasive species

Invasive species were noted throughout the site, but in minimal densities. Invasive species noted include Mimosa tree, Chinese lespedeza, clover species, common ragweed, princess tree and Japanese stiltgrass. At this point, they are not competing with the planted species for resources. Many invasive species observed within the site were also observed beyond the limits of disturbance in wooded areas; thus, their presence in a recently disturbed site is expected. Invasive species have the potential to overwhelm the native species, and will be monitored closely in the following year's surveys for an increase in their

population and coverage. The princess trees were growing under the powerlines along the driveway to 616 Magnolia Road and should be removed. No other eradication is recommended.

2.2. Geomorphic Assessment

2.2.1. Cross-sectional Surveys

Cross-sectional surveys were analyzed for bankfull width, mean depth, width/depth ratio, cross-sectional area, and discharge. These measurements are presented in Table 7 and graphical depictions of each cross section are presented in Appendix B. Bankfull elevations measured in the field match the top of the bank height associated with the design discharge at each cross section, and were therefore used to calculate the statistics presented in Table 7.

Cross sections 1 and 2 were established within the SRC at the upstream end of the restoration channel. Cross section 1 monitors a weir, while cross section 2 was established at a pool. Monitoring both features within the SRC will allow for a thorough analysis of the long term stability of the SRC system as a whole.

Cross sections 3 and 4 are located within the middle section of restoration, which utilized riffle-pool sequences. Cross section 3 was established in a riffle with riffle grade control stabilizing the channel bed. Cross section 4 is located across a pool, with stone toe protection stabilizing the right bank.

Cross section 5, located downstream of the driveway culvert, is in an area of stream that was minimally restored through grading of the right bank only. As a result the cross section is much wider than the restored cross section.

Table 7. Cross-sectional Analysis Statistics

Cross Section	Station	Feature	Bankfull Width (ft)	Mean Depth (ft)	Cross-Sectional Area (ft ²)	Width-Depth Ratio	Discharge (cfs)
1	0+43	SRC Weir	8.8	0.8	6.7	11.5	40.1
2	0+47	SRC Pool	11.6	1.5	17.8	7.6	164.9
3	3+28	Riffle	8.3	0.9	7.9	8.8	36.3
4	8+00	Pool	7.4	1.1	7.8	6.9	34.2
5	9+53	Riffle	11.3	1.3	14.8	8.6	79.7

At this time, and without multiple years to compare to, the cross sections appear to be stable with no undercut banks. Comparison with future monitoring events will indicate lateral migration and general bed movement.

2.2.2. Longitudinal Profile Survey

An analysis of the surveyed longitudinal profile allowed for the reach slopes to be calculated along the restored channel. Reaches and their corresponding slopes can be seen in Table 8 below.

Table 8. Longitudinal Profile Slope Comparison

Reach	Feature	Extent	Slope Year 1
1	SRC	Station 0+16 to 2+99	5.27%
2	Channel between SRC and step pools	Station 3+28 to 8+12	1.74%
3	Step Pools	Station 8+12 to 8+61	5.10%
4	Downstream of driveway culverts	Station 9+00 to 12+00	1.59%

Reach 1, through the SRC system, was designed with a steep slope due the constraints of adjacent private property and a high degree of channel entrenchment. The SRC allows the channel to have a higher slope while maintaining stability. Reach 2 begins immediately downstream of the SRC and extends downstream until just prior to the step pools. Reach 4 is the short step pool segment ending at the culvert invert. Reach 4, which was minimally restored, begins downstream of the driveway culvert and installed plunge pool and continues to the end of the restoration to the installed sill.

The surveyed longitudinal profiles are included in Appendix C and will be used as the baseline data for comparison with future monitoring events.

2.2.3. Radius of Curvature Survey

The radius of curvature was measured at three (3) meander bends to track potential lateral channel migration, with results in Table 9:

Table 9. Radius of Curvature Results

Meander Location	Radius (feet)
Station 5+50	32
Station 6+25	37
Station 7+75	57

2.2.4. Bed and Bank Stability

In general, the sediments of the mainstem's channel bed include coarse gravel to large cobble. The same material was used in the pools and riffles. Some bed material was observed to have migrated downstream forming a sediment bar near station 6+75. Bed and most bank scour is limited to the areas noted within close proximity to structures and is therefore discussed in the next section. One area of bank erosion is the largely unrestored segment from approximately 9+20 to 12+50. The right bank was graded to a 2:1 slope and stabilized with natural fiber matting and live stakes. At the time of the visual assessment of this area the live stakes that were still within the bank had not yet grown, the matting stakes were no longer fully sunk into the soil leaving the matting loose, and the bank was largely unprotected. It was unclear if there had been soil loss around the stakes or if the matting stakes had been elevated from soil heaving actions. The matting stakes are recommended to be reinstalled to help re-secure the matting and stabilize the bank without further action.

Pebble count results from the 3 riffles are provided in Table 10. The particle size distribution charts are included in Appendix D. The material collected from cross section 3, in a riffle grade control, is similar to the material specified for in the riffle grade control design. This is most noticeable at the top and bottom end of the size distribution, but becomes slightly less matched with the design specifications at the middle of the size range. This middle segment is slightly undersized based on the design specifications. The

sizing found at pebble counts 2 and 3, within channel bed material, is also fairly well aligned with the channel bed material called for in the design. Designed size ranges for both riffle grade controls and channel bed material are included in Appendix D.

Table 10. Pebble Count Material

Pebble Count ID	Location	Channel Material	Particle Size Distribution (mm)					
			D ₁₆	D ₃₅	D ₅₀	D ₆₅	D ₈₄	D ₉₅
1	XS 3	Riffle Grade Control	17	32	47	82	140	210
2	Station 6+88	Channel Bed Material	17	29	42	75	120	180
2	XS 5	Channel Bed Material	9.5	29	41	73	130	180

2.2.5. Evaluation of Channel and Bank Stabilization Structures

Stepped Riffle Complex (SRC)

The SRC was constructed from station 0+00 to 3+10, and includes a sequence of 16 pool, riffle-weir complexes. The entire SRC was inspected as a complete structure. SRC weirs are composed of boulders and appear stable throughout the system. SRC Pools were composed of a riffle grade control material. Overall the SRC pools are stable, though it looks that some movement of material has occurred throughout. In SRC pool 1 there appears to be some material that is not in contact with the surrounding materials as is throughout the pools, indicating they may have been mobilized at some point. Their movement has not created any areas of instability so the movement is not of concern.

Riffle Grade Control

The riffle grade control (RGC) uses sediments that were sized to resist a greater critical shear stress than boundary shear stress. This would therefore stabilize the channel bed and maintain its grades. The riffle grade controls were constructed between stations 3+12 and 3+40; 4+25 and 4+45; 5+00 and 5+25; 5+60 and 5+75; 6+50 and 6+80; 8+00 and 8+18; and 8+89 and 9+14.6. Upon inspection, all RGC structures appeared stable. The only other RGC with something worth noting is the downstream tie-in to existing grade at station 9+15. The tie-in is slightly elevated making a rise in the RGC bed which may produce scour over time within the existing bed.

Stone Sill

Stone sills were constructed at stations 9+00 and 12+00. The sill at 9+00 is stable and the scour pool directly downstream is also stable. The sill at 12+00 is located at the downstream extent of the restoration project. This structure is not failing but it is showing some signs of possible instability. This includes the separation of the sill stones, slight tilt to one of the central stones and scour at the downstream side of the sill. Additionally, the weir was installed at grade to the downstream existing bed when constructed, however, a scour hole is now visible for 8 feet downstream of the sill with overall channel downcutting visible. The signs of instability in the sill may be a result of shifting based on stopping the overall channel downcutting that has occurred, which was the purpose of this structure.

Step Pools

A series of three step pools were placed from 8+18 to 8+51 with crests at stations 8+18, 8+26, 8+34, 8+42, and 8+51. Each crest was observed to be stable, however, most of the pools were partially or fully filled with fine sediments or leaf litter. This is not anticipated to affect the stability as this material will be easily mobilized during a high flow event when the pools are scoured and needed for energy dissipation.

Stone Toe Protection

Stone toe protection was placed in the mainstem along the outer bends of meanders, along some of the riffle grade control structures, and where a drainage enters the stream. On the left bank, this includes from station 5+92 to 6+80. On the right bank, this includes from stations 4+65 to 5+75; and 7+25 to 8+20. The stone toe protection is designed to harden the banks and prevent erosion and lateral migration of the channel. The majority of stone toe protection materials are sufficiently large with no indication of dislodging. However, in two locations the up or downstream key-in to a non-stone bank is of minor concern. The upstream key-in at 4+65 on the right bank shows some scour and the downstream tie-in at 5+75 is elevated such that it has a high potential for inducing scour under some flow conditions. Despite this, no portions of the stone toe appear to be slumping or failing. Thus far, all stone toe protection is functioning as designed, but will be visually monitored for movement and erosion behind the stones.

2.3. Physical Habitat Evaluation

Physical habitat evaluations were conducted concurrently with biological sampling on April 15, 2016. The summary results of the RBP and PHI habitat assessments are presented in Table 11. Complete habitat assessment results are presented in Appendix E. The percent comparability to RBP reference scores ranged from 52.0 percent at WOOD-US to a high of 57.5 percent at site WOOD-DS, with both sites receiving classifications of 'Non-Supporting.' The MBSS reference site, LWIN-108, was not evaluated using the RBP method. Similar assessment results were observed using the PHI index, where site WOOD-US received the lowest score of 55.18 and a narrative rating of 'Degraded' and site WOOD-DS received the highest score of 60.32 and a rating of 'Degraded.' The MBSS reference site (LWIN-108) was also rated as 'Degraded,' with a PHI score of 62.70.

Table 11. Physical Habitat Assessment Results 2015

Site	Total RBP	RBP % of Reference	RBP Classification	PHI Score	PHI Narrative Rating
WOOD-US	104	52.0	Non-Supporting	55.18	Degraded
WOOD-DS	115	57.5	Non-Supporting	60.32	Degraded
LWIN-108	n/a	n/a	n/a	62.70	Degraded

n/a = not applicable

A comparison of post-construction results from 2015, to pre-construction data from 2005 – 2007 is presented below in Figure 3. Both sites show slightly improved PHI scores compared with pre-construction conditions. There is no longer a downward trend of declining habitat scores, most of which were previously attributed to accelerated bank erosion and sedimentation. It is likely that the PHI scores will improve once the vegetation begins to fill in, improving shading and woody input to the stream channel.

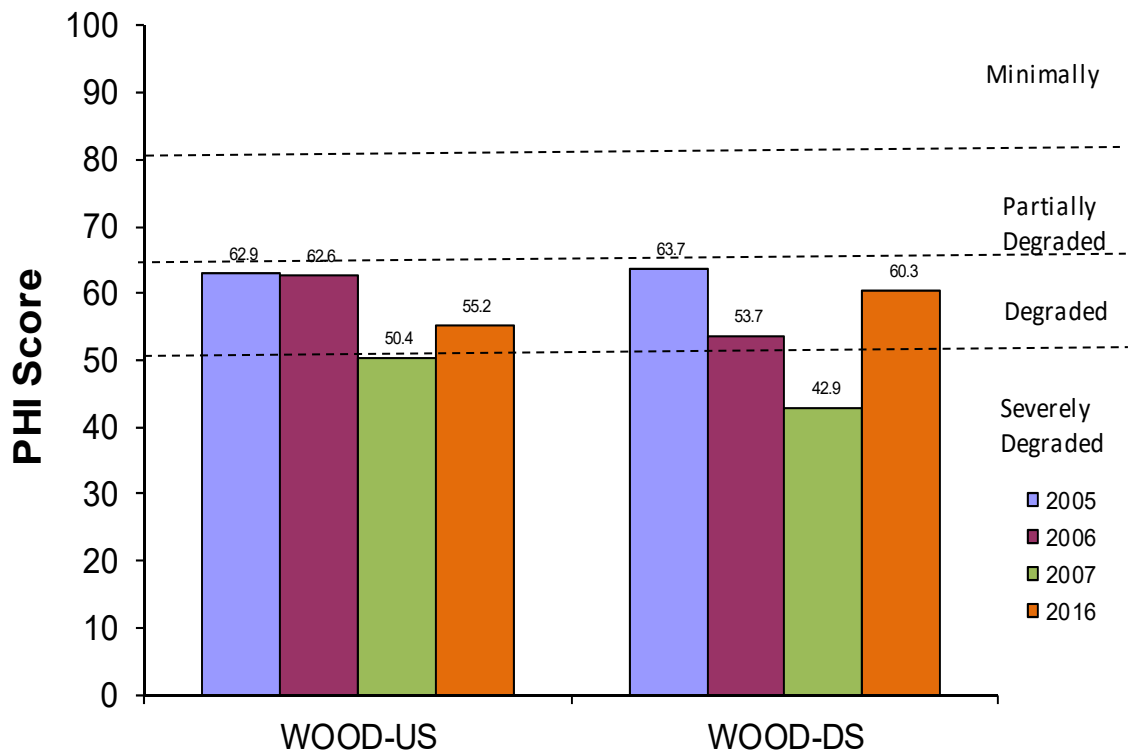


Figure 3. Comparison with Pre-Construction (2005-2007) PHI Scores

2.4. Biological Monitoring

Benthic macroinvertebrate sampling was conducted at the two (2) biological monitoring sites on April 15, 2016. Both sites received ‘Very Poor’ biological condition ratings, with BIBI scores ranging from 1.00 to 1.86. At the downstream restoration reach, WOOD-DS, there were 125 individuals identified in the sample, comprising only 11 taxa. The sample was dominated by Naididae (Tolerance Value [TV] = 8.5), a family of pollution tolerant oligochaete worms. There were only 2 EPT Taxa present and no ephemeroptera taxa. Only one scraper taxa was present, and both intolerant individuals and climbers were present in very low amounts, 2.0% and 3.2%, respectively. The upstream restoration reach, WOOD-US, also had only 11 taxa present in the 116-organism subsample. Only a single EPT taxon was present, and ephemeroptera and scraper taxa were both absent. Like WOOD-DS, the sample was dominated by pollution tolerant oligochaete worms.

Table 12. Benthic Index of Biotic Integrity (BIBI) Summary Data 2016

Metric	WOOD-DS	WOOD-US
Metric Values		
Total Number of Taxa	11	11
Number of EPT Taxa	2	1
No. of Ephemeroptera Taxa	0	0
Percent Intolerant Urban	2	0
Percent Ephemeroptera	0.0	0
Number Scraper Taxa	1	0
Percent Climbers	3.2	0
Metric Scores		
Total Number of Taxa	1	1
Number of EPT Taxa	3	1
No. of Ephemeroptera Taxa	1	1
Percent Intolerant Urban	1	1
Percent Ephemeroptera	1	1
Number Scraper Taxa	3	1
Percent Climbers	3	1
BIBI Score	1.86	1.00
Narrative Rating	Very Poor	Very Poor

Results from the MBSS reference site (LWIN-108), which was sampled during the spring 2015 index period, are presented in Table 13. It is worth noting that the pre-construction reference site was not able to be sampled due to issues with property owner permissions, and that a nearby MBSS urban reference reach has been selected to serve as the new reference site moving forward. This site is located in the adjacent Winters Run watershed, however, it is within the piedmont physiographic region. Subsequently, the MBSS piedmont were used to calculate the BIBI score. Overall, the site received a BIBI score of 3.00 and a corresponding narrative rating of 'Fair.' The 120-organism subsample was represented by 28 taxa, eight (8) of which were EPT taxa. One ephemeroptera taxon, *Eurylophella* (TV = 4.5), was present in the sample. Intolerant individuals comprised 29% of the sample, and clingers comprised 69%.

Table 13. MBSS Reference Site Benthic Index of Biotic Integrity (BIBI) Summary Data 2016

Metric	LWIN-108
Metric Values	
Total Number of Taxa	28
Number of EPT Taxa	8
Number of Ephemeroptera Taxa	1
Percent Intolerant Urban	29
Percent Chironomidae	44
Percent Clingers	69
Metric Scores	
Total Number of Taxa	5
Number of EPT Taxa	3
Number of Ephemeroptera Taxa	1
Percent Intolerant Urban	3
Percent Chironomidae	3
Percent Clingers	3
BIBI Score	3.00
Narrative Rating	Fair

A comparison of post-construction results from 2015, to pre-construction data from 2005 – 2007 is presented below in Figure 4. It is important to note that both sites had to be shifted slightly in 2015 from the previously established locations as a result of the stream restoration activities. The upstream site was shifted from above Magnolia Road in the pre-restoration phase to immediately below Magnolia Road in the post-restoration phase. Therefore, comparisons in BIBI scores between pre- and post-construction periods need to account for this difference. WOOD-DS shows fairly consistent BIBI scores from pre- to post-construction conditions. WOOD-US, on the other hand, shows a decline in post-construction BIBI scores. However, even at the reference site, deviations occur in the BIBI scores from year-to-year resulting from natural variation (see Figure 5). Although, it is also likely that the BIBI scores will improve once the benthic macroinvertebrate community has an opportunity to recover from the disturbance caused by the stream construction.

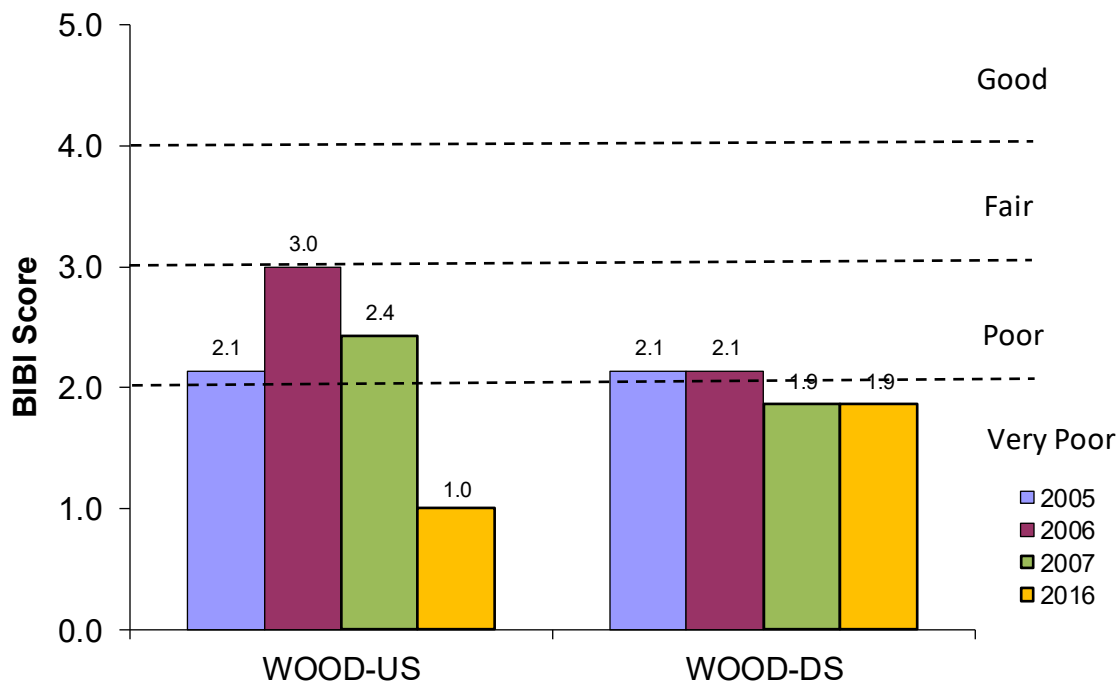


Figure 4. Comparison with Pre-Construction (2005-2007) BIBI Scores

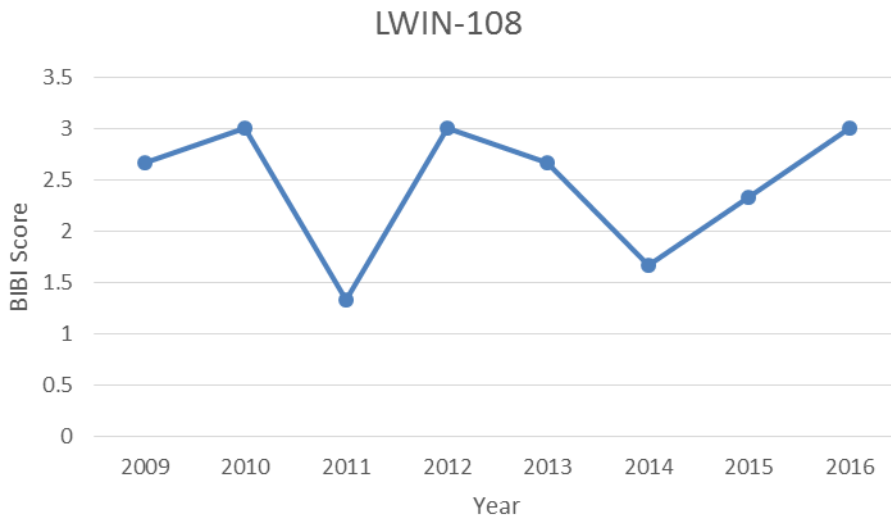


Figure 5. Comparison of BIBI Scores at the MBSS Reference Site (2009-2015)

3. CONCLUSIONS

The Year 1 (2016) geomorphic monitoring and structure inspections show a stream channel that is overall stable and functioning as designed. The few areas of erosion near the RGC, stone toe protection key-in should be specifically observed for increased deterioration. It is possible these areas will stabilize over the next year due to the increase in vegetative development. The right bank of the unrestored segment approximately 9+20 to 10+00 should be rematted, or stakes reset to secure the existing matting. The stone sill at 12+00 showed the greatest potential of failure yet its purpose is to mitigate such deterioration. No action is recommended at this time for the downstream sill due to its potential to stabilize with increased vegetation growth, lack of immediate cascading failures upstream if it were to fail and location on private property.

Overall, all planted landscape zones were extremely vigorous and successful. Trees, shrubs, and live stakes all had excellent survival and were found to be in excellent health. Aside from the poor herbaceous survival at the upstream end on the right bank, likely due to road runoff, the herbaceous zone and turf grass zones were very successful and had excellent coverage. All zones passed the warranty survival requirement of 85%. Minimal invasive species were noted, however the princess trees under the power lines should be removed. It is recommended that the area downstream of the culvert on the right bank from 9+50 to 10+00 be replanted with live stakes. Additionally, the existing mature trees should continue to be monitored for signs of construction stressors.

Impacted biological and physical habitat conditions are currently present following construction of the stream restoration project. These results are expected since it often takes time for the macroinvertebrate community to recover following a substantial disturbance, such as construction of a new stream channel. Furthermore, physical habitat conditions have also been impacted by the recent construction, and it will also take time for the vegetation to thrive and create more heterogeneous and functional habitat conditions within and around the channel. Biological potential is limited by the quality of the physical habitat, which forms the template upon which biological communities develop (Southwood, 1977). As the habitat conditions improve and the benthic macroinvertebrate community begins to recolonize the stream, it is expected that improvements to the biological conditions will be seen during future assessments.

4. REFERENCES

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington D.C.
- Boward, D. and E. Friedman. 2000. Maryland Biological Stream Survey Laboratory Methods for Benthic Macroinvertebrate Processing and Taxonomy. Maryland Department of Natural Resources Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-00-6.
- Harrelson, C.C., Rawlins, C.L. and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. United States Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- KCI Technologies, Inc. (KCI). 2013. Geomorphic Monitoring Spreadsheet. Sparks, MD.
- Leopold, L. B., H. L. Silvey, D. L. Rosgen. 2000. The River Field Book. Western Hydrology: Pagosa Spring, Colorado.
- Maryland Department of Natural Resources (DNR). 2014. Maryland Biological Stream Survey: Round Four Sampling Manual. Maryland Department of Natural Resources, Annapolis, MD. Publication #12-121-491. January 2015.
- Mecklenburg, D. 2006. The Reference Reach Spreadsheet – For Channel Survey Data Management v. 4.3 L. Ohio Department of Natural Resources.
- Paul, M.J., Stribling, J.B., Klauda, R.J., Kazyak, P.F., Southerland, M.T., and N.E. Roth. 2003. A Physical Habitat Index for Freshwater Wadeable Streams in Maryland. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD. CBWP-MANTA-EA-03-4.
- Rosgen, Dave. 1996. Applied River Morphology. Hilton Lee Silvey, Lakewood, Colorado.
- Rosgen, D. 2006. Watershed Assessment of River Stability and Sediment Supply (WARSS). Wildland Hydrology, Fort Collins, Colorado. Copyright 2006. Details can be accessed online at <http://www.epa.gov/warsss/pla/box08.htm>.
- Southerland, M.T., G.M. Rogers, M.J. Kline, R.P. Morgan, D.M. Boward, P.F. Kazyak, R.J. Klauda, S.A. Stranko. 2005. New Biological Indicators to Better Assess the Condition of Maryland Streams. DNR-12-0305-0100. Maryland Department of Natural Resources, Monitoring and Non-Tidal Assessment Division. Annapolis, MD.
- Southwood, T.R.E. 1977. Habitat, the template for ecological strategies? *Journal of Animal Ecology* 46:337-365.
- Wolman, M.G. 1954. A method of sampling coarse river-bed material. *Transactions American Geophysical Union*. Volume 35. Number 6. Pages 951-956

APPENDIX A
Site Photographs

Right and left banks are determined facing downstream



Facing upstream of poor establishment in turf grass zone near road at station 0+00



View facing downstream of excellent tree survival and poor herbaceous establishment in riparian zone on right bank from station 0+00

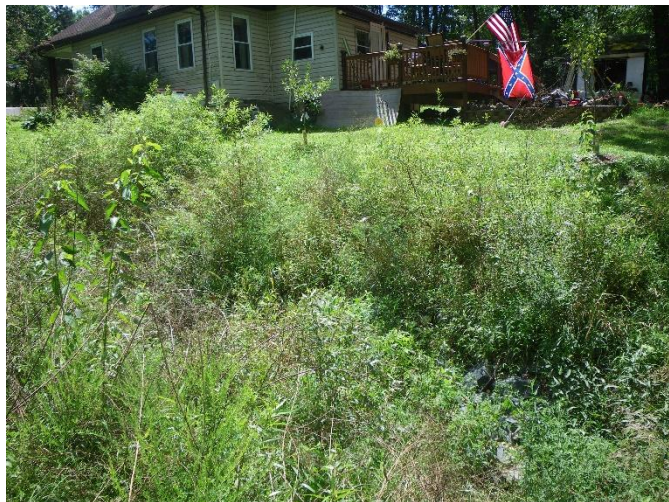


View facing upstream from station 0+25



View facing downstream of excellent live stake growth from station 0+25

Right and left banks are determined facing downstream



View facing left bank of excellent live stake growth from station 2+00



View of poor herbaceous establishment on right bank from station 2+00



View facing upstream tributary on right bank at station 2+25



View facing downstream of vigorous live stake growth from station 2+25

Right and left banks are determined facing downstream



View facing upstream tributary on right bank at station 2+75



View facing upstream turf grass zone on right bank from station 2+75



View facing downstream of vigorous live stakes and vegetation in channel from station 2+75



View facing downstream riparian zone on left bank from station 2+75

Right and left banks are determined facing downstream



View facing upstream of vigorous herbaceous establishment in riparian zone from station 4+00



View facing downstream of excellent tree and shrub survival on left bank from station 4+00



View facing left bank of sedge and rush volunteers in riparian zone from station 4+50



View of bare spot around existing trees on left bank from station 5+25 to 5+50

Right and left banks are determined facing downstream



View facing downstream of dense deer tongue grass on right bank from station 5+50



View facing downstream of dense jewelweed in channel from station 6+00



View of skeletonized viburnum leaves, likely from viburnum leaf beetle or Japanese beetle



View facing downstream from station 7+00

Right and left banks are determined facing downstream



View facing downstream riparian zone from station 7+00



View facing upstream tributary on right bank from station 7+40



View facing right bank of vigorous willow live stakes from
station 7+75



View facing upstream of princess trees at driveway road culvert

Right and left banks are determined facing downstream



View of turf grass zone on upstream side of road culvert



View facing downstream from driveway road culvert



View of riparian zone on left bank at driveway road culvert



View facing downstream of eroded right bank and dead live
stakes from station 9+50 to 10+00

Right and left banks are determined facing downstream



View facing right bank turf zone from station 9+75



View facing upstream from station 10+00



View facing downstream from station 10+00



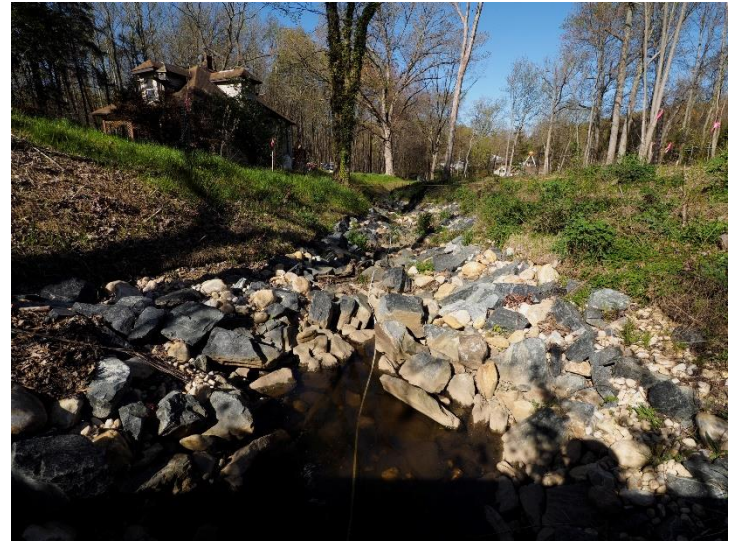
View facing upstream from station 11+25

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 0+00 facing downstream; culvert invert



Station 0+09 facing downstream



Station 0+43 at cross section 1 facing downstream



Station 0+43 at cross section 1 facing left bank

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 0+43 at cross section 1 facing right bank



Station 0+47 at cross section 2 facing downstream



Station 0+47 at cross section 2 facing left bank



Station 0+47 at cross section 2 facing right bank

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 0+55 facing downstream



Station 0+70 facing downstream



Station 1+40 facing downstream



Station 1+71 facing downstream

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 1+90 facing downstream



Station 2+25 facing downstream; pool and downstream riffle are dry



Station 2+60 facing downstream



Station 2+87 facing downstream; tributary confluence on right bank

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 2+92 facing downstream



Station 3+28 at cross section 3 facing downstream



Station 3+28 at cross section 3 facing left bank



Station 3+28 at cross section 3 facing right bank

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



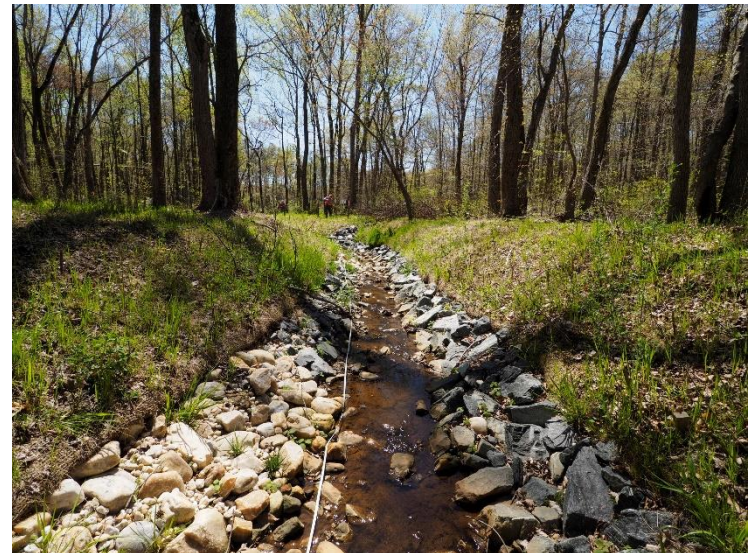
Station 3+46 facing downstream



Station 3+72 facing downstream



Station 4+65 facing downstream



Station 5+05 facing downstream

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 5+50 facing downstream



Station 5+81 facing downstream



Station 6+10 facing downstream



Station 6+55 facing downstream

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 7+32 facing downstream



Station 8+00 at cross section 4 facing downstream



Station 8+00 at cross section 4 facing left bank



Station 8+00 at cross section 4 facing right bank

Right and left banks are determined facing downstream



Station 8+25 facing downstream



Station 8+40 facing downstream towards driveway culvert



Station 8+85 at downstream end of driveway culvert facing downstream



Station 9+00 facing downstream

Right and left banks are determined facing downstream



Station 9+53 at cross section 5 facing left bank



Station 9+53 at cross section 5 facing right bank



Station 9+53 at cross section 5 facing downstream



Station 9+70 facing downstream

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 10+00 facing downstream



Station 10+20 facing downstream



Station 10+40 facing downstream



Station 11+20 facing downstream

Right and left banks are determined facing downstream

Woodbridge Year 1 post-construction Monitoring
Geomorphic Assessment Photographs



Station 11+40 facing downstream



Station 11+80 facing downstream



Station 12+00 at weir facing downstream



Station 12+25 facing downstream

Right and left banks are determined facing downstream



Station 0+10 facing left bank; possibly dislodged stones from pool



Station 0+80 facing left bank; cut tree in channel



Station 1+75 facing downstream; stepped riffle complex weirs look stable



Station 2+25 facing right bank; pool and downstream riffle are dry

Right and left banks are determined facing downstream



Station 2+50 facing right bank; cobble material potentially pushed up/out of pool



Station 2+87 facing right bank at tributary confluence; tributary tie-in is stable



Tributary facing left bank; upstream key-in is stable



Tributary facing right bank; upstream key-in is stable



Station 3+20 facing downstream; riffle grade control is stable



Station 3+50 facing downstream; minor left bank scour just downstream of riffle grade control



Station 3+50 facing left bank; minor bank scour just downstream of riffle grade control



Station 4+25 facing downstream; riffle grade control stable with good side slope correction; no scour at downstream end



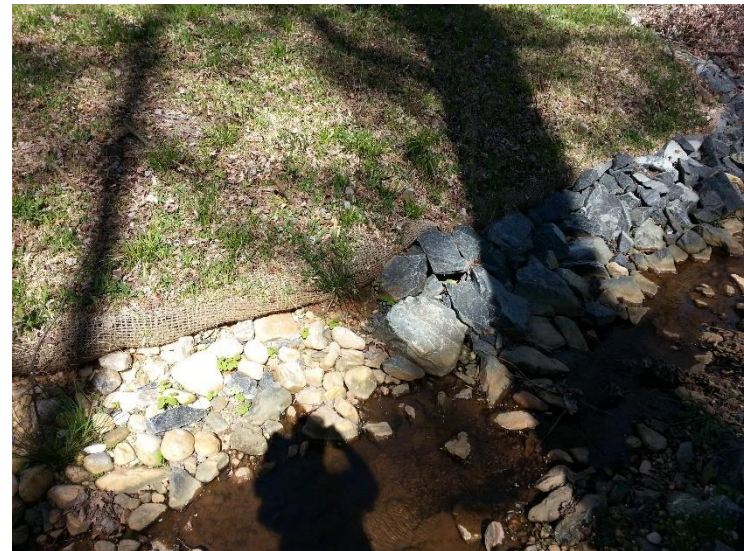
Station 4+65 facing right bank stone toe protection; small scour at key-in but cause uncertain, otherwise stable



Station 4+95 facing downstream; riffle grade control and stone toe protection stable



Station 5+50 facing downstream; riffle grade control stable with good blended appearance



Station 5+80 facing right bank; stone toe protection tie-in a little perched

Right and left banks are determined facing downstream



Station 5+90 facing left bank; stable stone toe protection tie-in



Station 6+30 facing downstream; point bar formation/tailout



Station 6+50 facing downstream; riffle grade control stable



Station 6+90 facing right bank; transition between stone toe protection and channel bed material



Station 7+51 facing right bank seep channel; tie-in is stable



Station 7+51 facing downstream; stone toe protection and seep channel tie-in is stable with some deposition



Station 7+90 facing downstream; stone toe protection more "stacked" than laid back, but stable



Station 8+30 facing downstream at debris collector installed by property owner



Station 8+27 facing downstream; weir 1 and weir 2 are stable; pool 1 is filled



Station 8+50 facing downstream; pool 2 is not visible (same depth); weir 3 is stable, but has gravel and leaves on top



Station 8+85 facing right bank and sill at station 9+00; pool downstream of driveway culvert is stable



Station 9+00 facing downstream; riffle grade control is stable



Station 9+25 facing downstream; material in channel likely causing minor left bank scour



Station 9+25 facing upstream; downstream tie-in of riffle grade control to existing stream bed slightly elevated



Station 9+75 facing downstream; about 40' of no work area is degraded



Station 10+40 facing downstream; landscaping stakes present should be pounded into bank or removed and cut fabric; clay toe is stable

Right and left banks are determined facing downstream



Station 11+90 facing downstream; sill top stones have scour visible on left bank



Station 12+00 facing right bank; scour downstream of sill



Station 12+00 facing left bank; scour downstream of sill

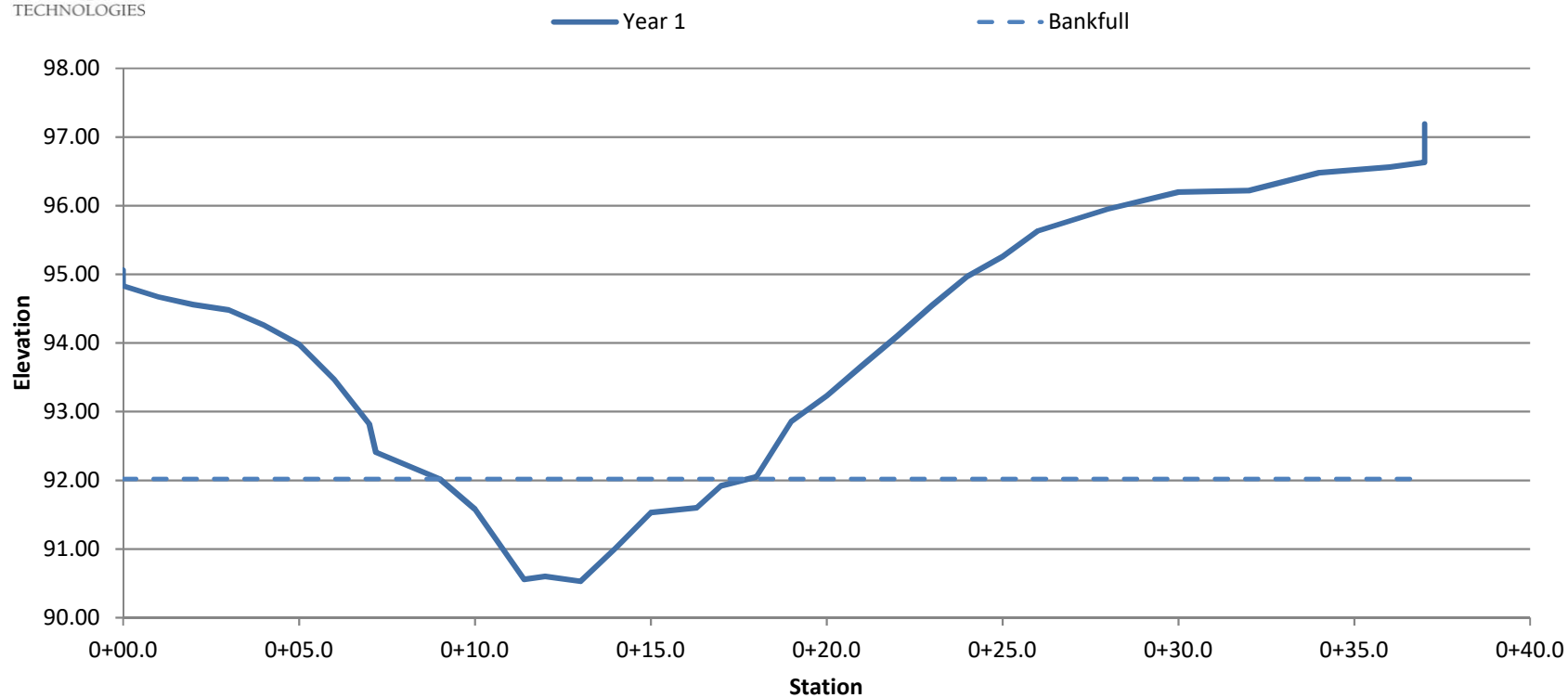


Station 12+15 facing upstream; scour downstream of sill on banks and bed

APPENDIX A-1
Vegetation Assessment Photographs



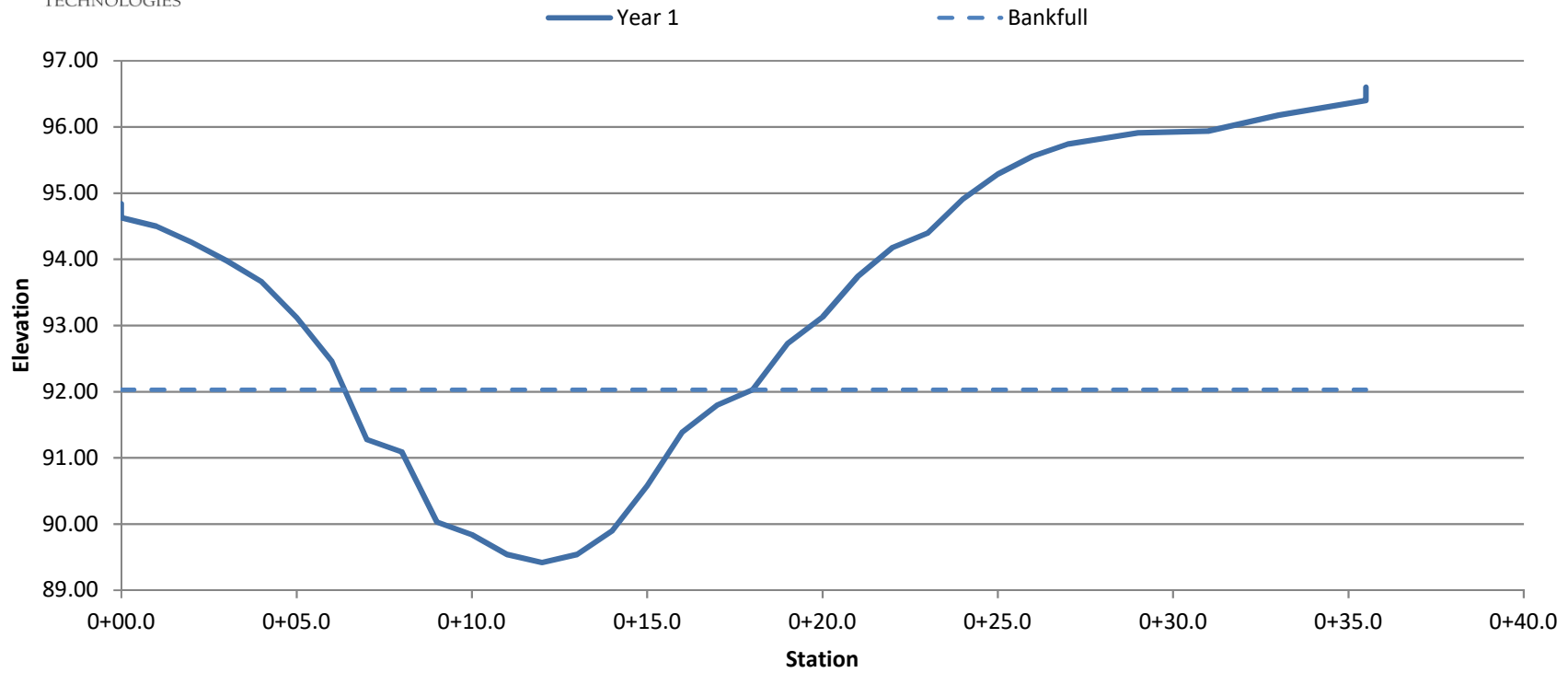
Cross Section 1



BKFL/TOB ELEV=	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
92.02					
YEAR-1	8.8	0.8	6.7	11.5	40.1



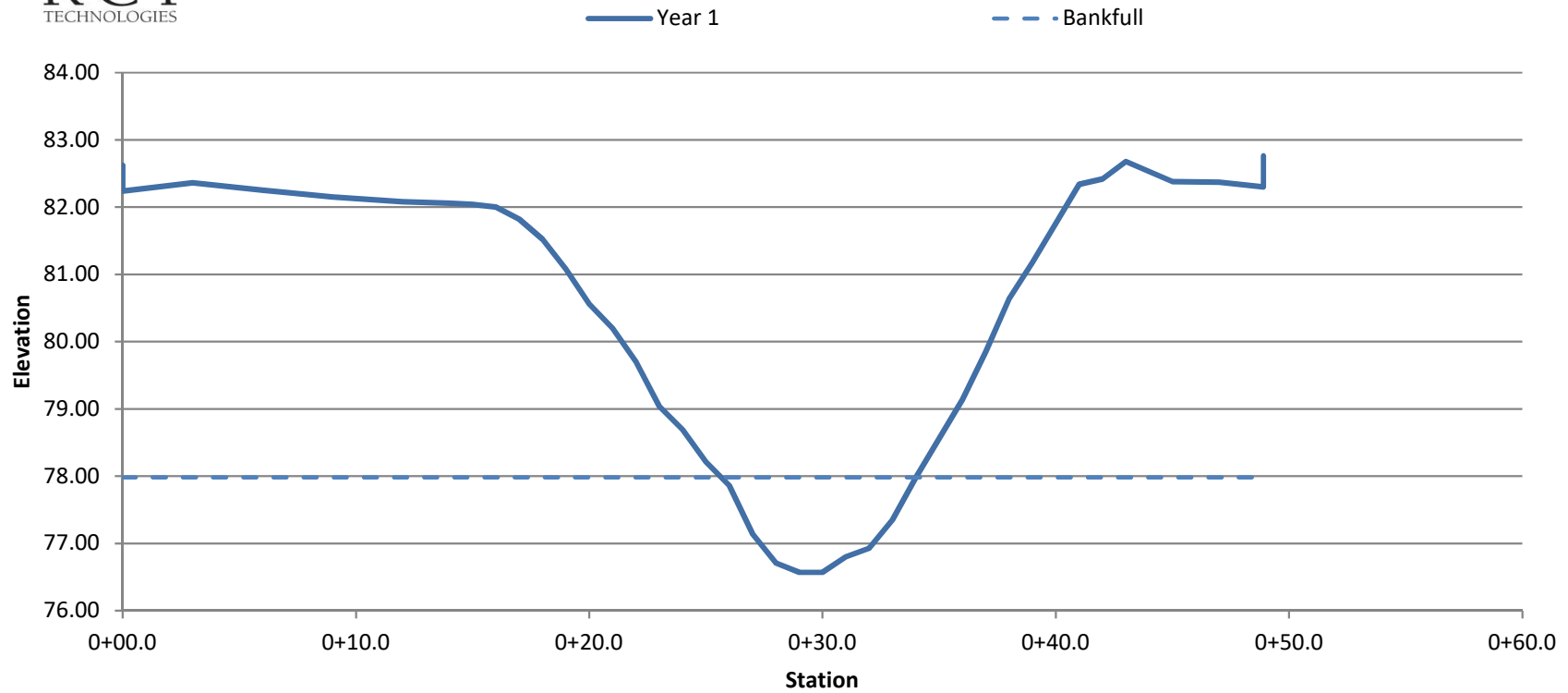
Cross Section 2



BKFL/TOB ELEV=	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
92.03					
YEAR-1	11.6	1.5	17.8	7.6	164.9



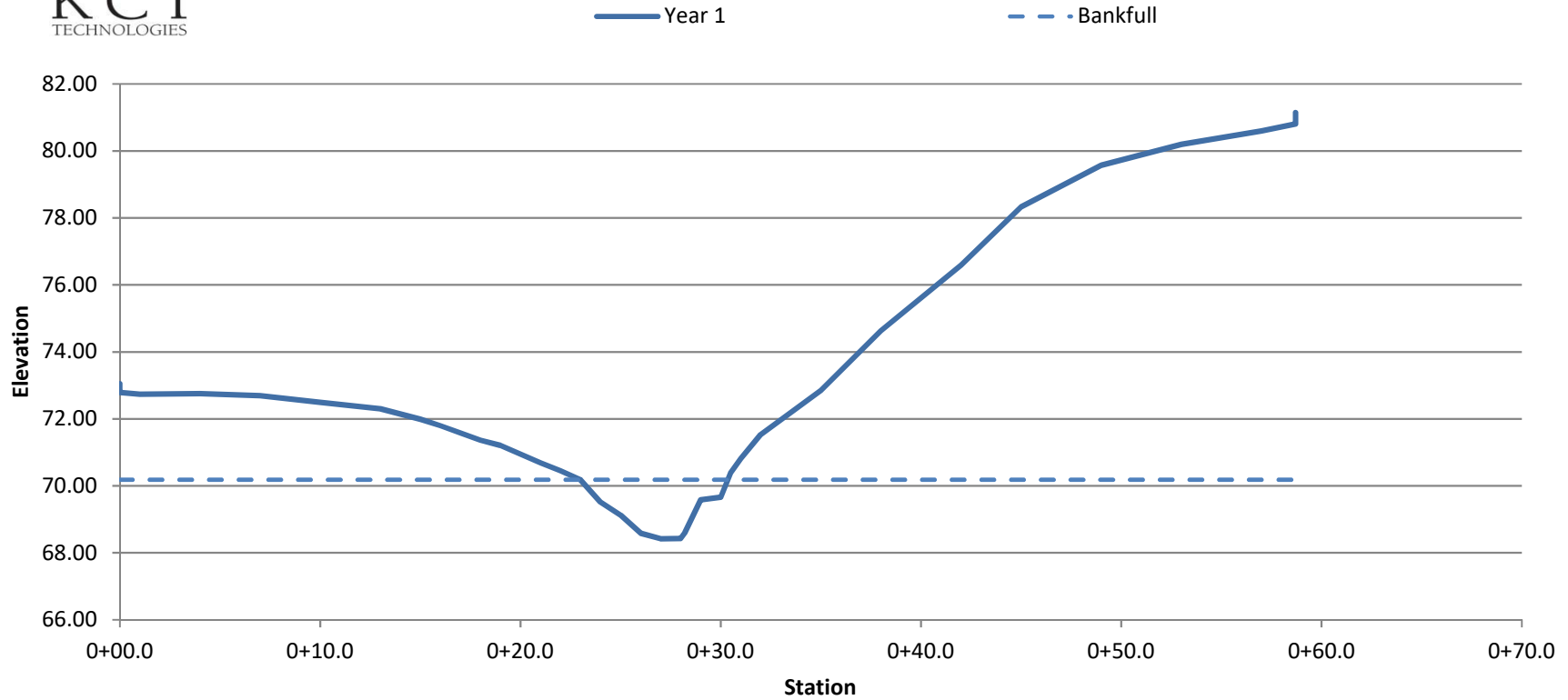
Cross Section 3



BKFL/TOB ELEV=	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
77.98					
YEAR-1	8.3	0.9	7.9	8.8	36.3



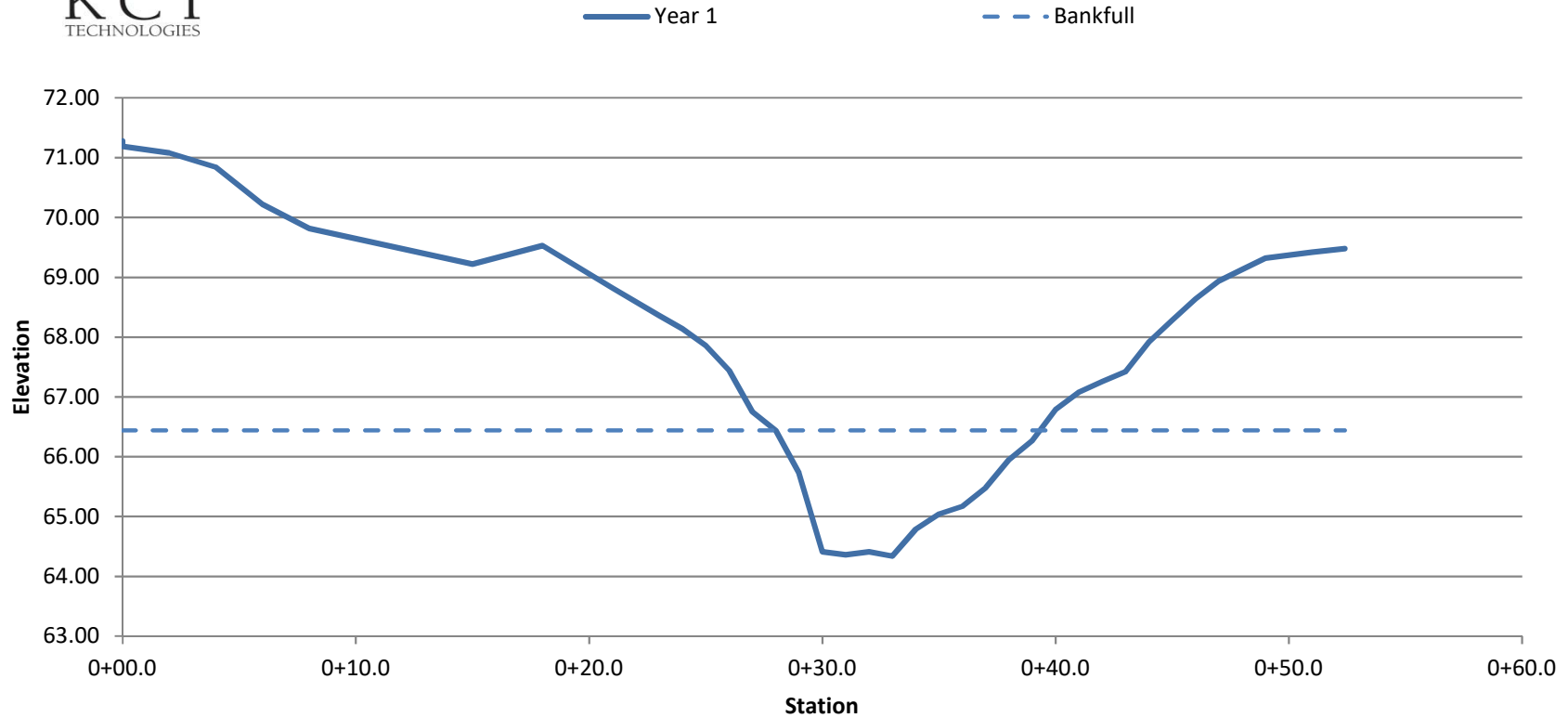
Cross Section 4



BKFL/TOB ELEV=	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
70.18					
YEAR-1	7.4	1.1	7.8	6.9	37.1



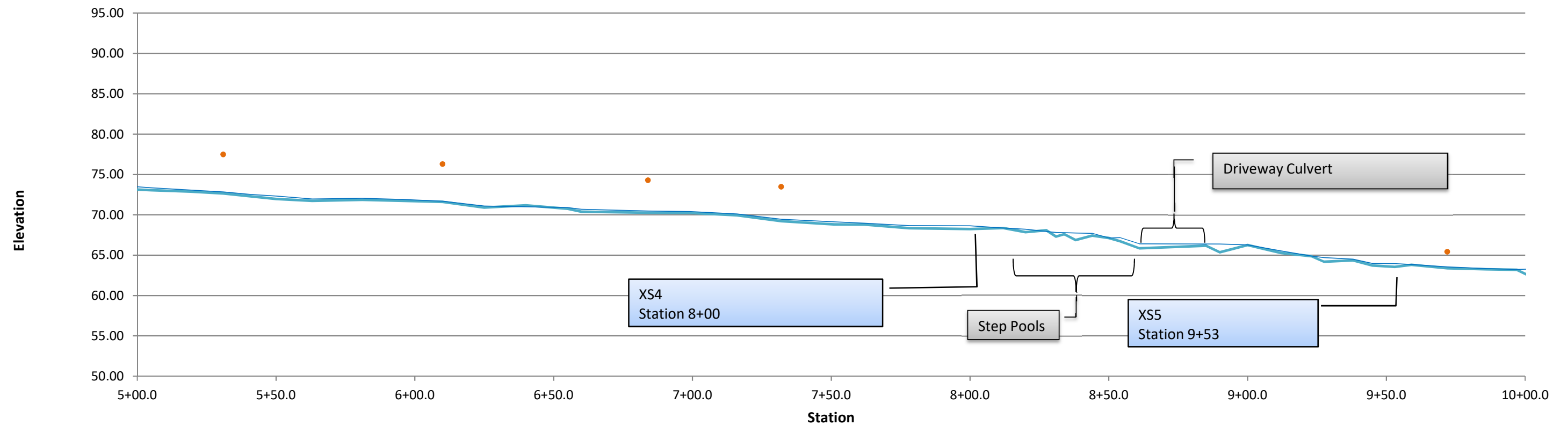
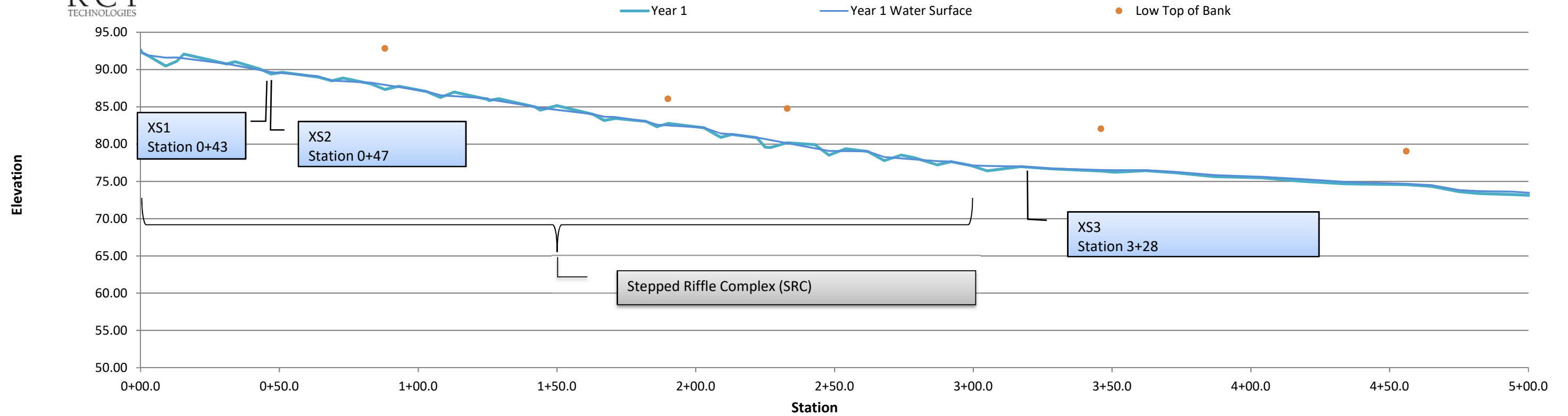
Cross Section 5



BKFL/TOB ELEV=	WIDTH (FT)	MEAN DEPTH (FT)	CROSS SECTION AREA (SQ FT)	WIDTH-DEPTH RATIO	DISCHARGE (cfs)
66.44					
YEAR-1	11.3	1.3	14.8	8.6	79.7



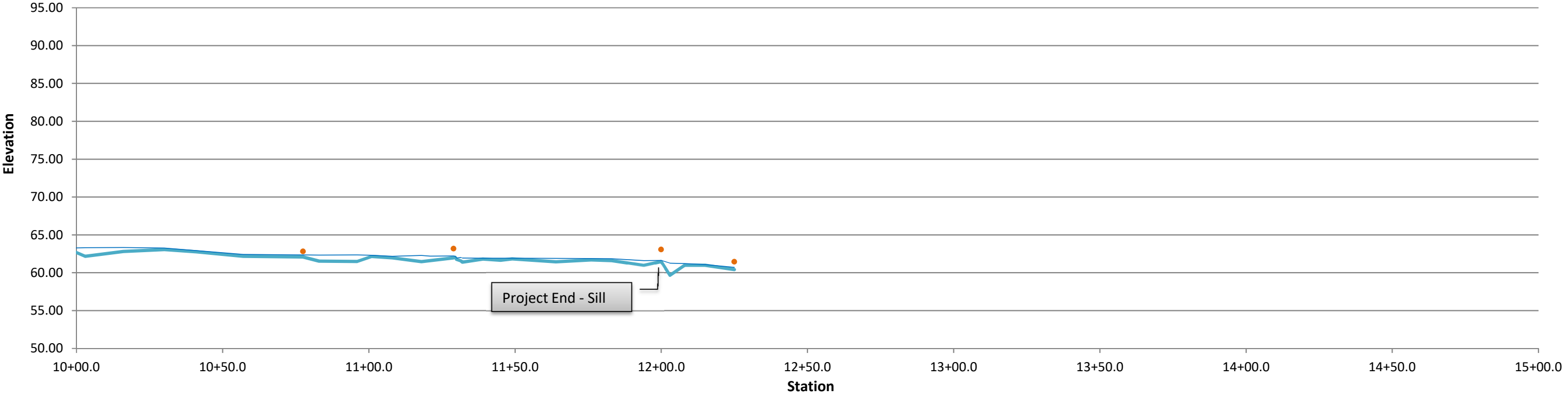
Woodbridge Year 1 Post-construction Monitoring





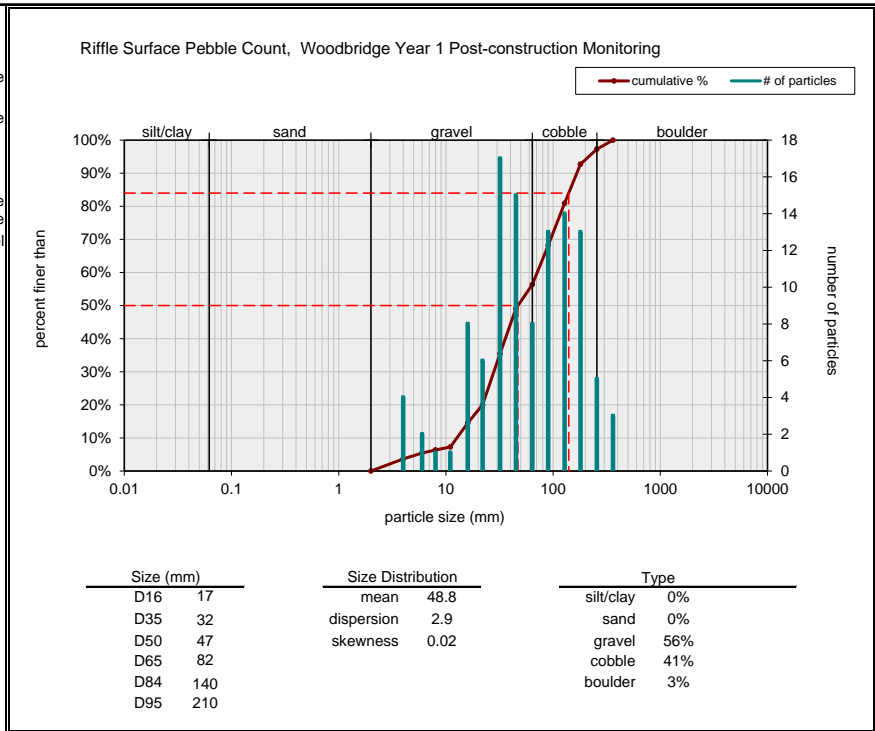
Woodbridge Year 1 Post- construction Monitoring

Year 1 Year 1 Water Surface Low Top of Bank

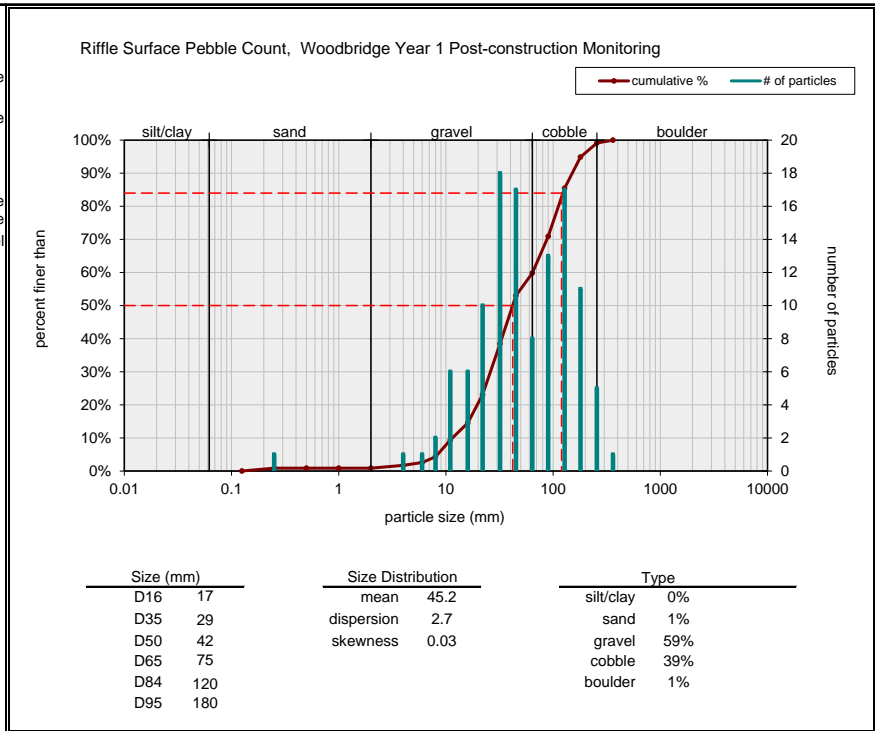


APPENDIX A-2
Geomorphic Assessment Photographs

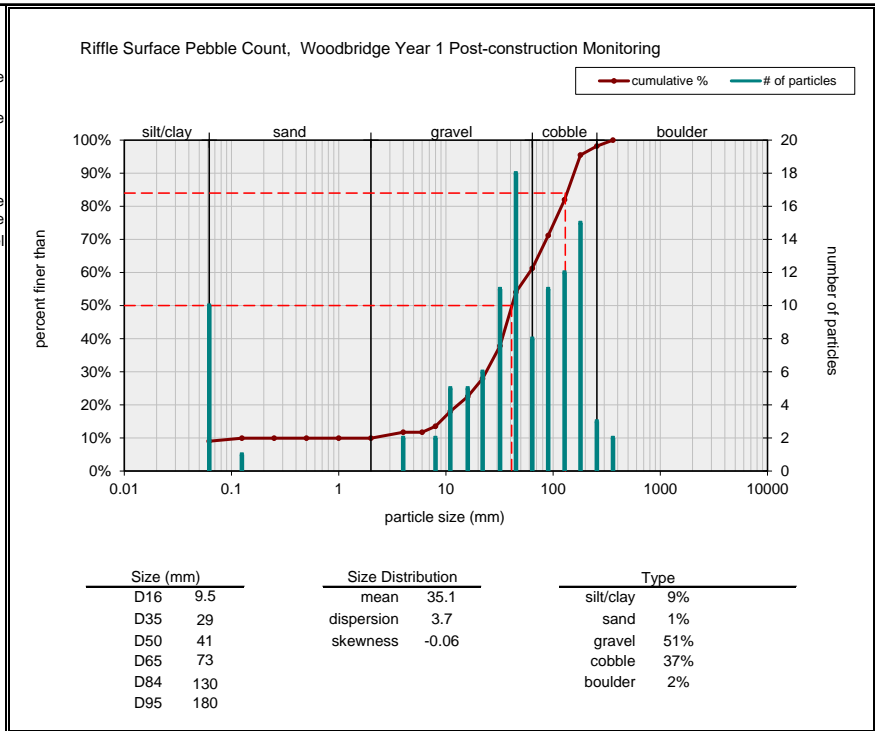
Riffle Surface		
Material	Size Range (mm)	Count
silt/clay	0 - 0.062	
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	4
fine gravel	4 - 6	2
fine gravel	6 - 8	1
medium gravel	8 - 11	1
medium gravel	11 - 16	8
coarse gravel	16 - 22	6
coarse gravel	22 - 32	17
very coarse gravel	32 - 45	15
very coarse gravel	45 - 64	8
small cobble	64 - 90	13
medium cobble	90 - 128	14
large cobble	128 - 180	13
very large cobble	180 - 256	5
small boulder	256 - 362	3
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		110
bedrock -----		
clay hardpan -----		
detritus/wood -----		
artificial -----		
total count:		110
Note: xs-3, riffle grade control		



Riffle Surface		
Material	Size Range (mm)	Count
silt/clay	0 - 0.062	
very fine sand	0.062 - 0.125	
fine sand	0.125 - 0.25	1
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	1
fine gravel	4 - 6	1
fine gravel	6 - 8	2
medium gravel	8 - 11	6
medium gravel	11 - 16	6
coarse gravel	16 - 22	10
coarse gravel	22 - 32	18
very coarse gravel	32 - 45	17
very coarse gravel	45 - 64	8
small cobble	64 - 90	13
medium cobble	90 - 128	17
large cobble	128 - 180	11
very large cobble	180 - 256	5
small boulder	256 - 362	1
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		117
bedrock -----		
clay hardpan -----		
detritus/wood -----		
artificial -----		
total count:		117
Note: 6+88, channel bed material		



Riffle Surface		
Material	Size Range (mm)	Count
silt/clay	0 - 0.062	10
very fine sand	0.062 - 0.125	1
fine sand	0.125 - 0.25	
medium sand	0.25 - 0.5	
coarse sand	0.5 - 1	
very coarse sand	1 - 2	
very fine gravel	2 - 4	2
fine gravel	4 - 6	
fine gravel	6 - 8	2
medium gravel	8 - 11	5
medium gravel	11 - 16	5
coarse gravel	16 - 22	6
coarse gravel	22 - 32	11
very coarse gravel	32 - 45	18
very coarse gravel	45 - 64	8
small cobble	64 - 90	11
medium cobble	90 - 128	12
large cobble	128 - 180	15
very large cobble	180 - 256	3
small boulder	256 - 362	2
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
total particle count:		111
bedrock -----		
clay hardpan -----		
detritus/wood -----		
artificial -----		
total count:		111
Note: xs-5, channel bed material		



Designed Material Size Distributions

Riffle Grade Control

% Less Than	Size (mm)
10	20
30	76
50	112
60	152
84	198
100	224

Channel Bed Material

% Less Than	Size (mm)
16	10
30	25
50	41
85	140
100	178

APPENDIX A-3
Structure Assessment Photographs

Project Name: Woodbridge Post-Construction Biomonitoring
Project Number: 17134556.03
Prepared by: CH
Prepared date: 10/26/16

PHI_Coastal_Plain_v2_Wood.xlsx
Checked by: AJB
Checked date: 10/27/2016

Version: 1
Site Name:



Raw Data													Scaled Metrics						Rating	
Site	Subshed Area (acres)	Instream Habitat	Epibenthic Substrate	Velocity Depth Diversity	Pool Glide Eddy Quality	Bank Stab (0-20)	Embeddedness	Percent Shading	Aesthetics (Trash)	Remoteness Score	# Woody Debris/ Rootwads	Max Depth	Instream Habitat	Epibenthic Substrate	Bank Stability	Shading	Remoteness	# Woody Debris/ Rootwads	PHI	PHI Rating
Wood US	35	2	3	6	6	20	20	30	11	2	0	37	55.40	50.48	100.00	31.57	12.14	81.46	55.18	Degraded
Wood DS	70	6	8	7	6	20	20	30	17	2	0	24	70.50	75.01	100.00	31.57	11.21	73.61	60.32	Degraded

Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Project Name: Woodbridge Post-Construction Biomonitoring
 Project Number: 17134556.03
 Prepared by: CH
 Prepared date: 10/26/16

PHI_Piedmont_v3_Ref.xlsx
 Checked by: AJB
 Checked date: 10/27/2016

Version: 2
 Site Name: _____



RAW DATA								SCALED METRICS								SCORES			
Site	Subshed Area (ac)*	Instream Habitat	Epibenthic Substrate	Embeddedness	Percent Shading	# Woody Debris/ Rootwads	Riffle Quality	Bank Stability	Remoteness Score	Instream Habitat	Epibenthic Substrate	Embeddedness	Percent Shading	# Woody Debris/ Rootwads	Riffle Quality	Bank Stability	Remoteness	PHI	PHI Rating
LWIN-108	411	15	15	20	85	2	16	2	9	87.47	82.35	88.89	77.04	16.67	100.00	12.77	54.03	64.9	Degraded

Score	Narrative Rating
81-100	Minimally Degraded
66.0-80.9	Partially Degraded
51.0-65.9	Degraded
0-50.9	Severely Degraded

Project Name: Woodbridge Post-Construction Biomonitoring

Project Number: 17134556.03

Prepared by: SL

Prepared date: 4/16/16

Checked by: CH

Checked date: 10/26/16

RBP_Woodbridge_High_Gradient_v1.xlsx

Version: 1

Site Name: Woodbridge



STATION ID	DATE	ESC	E	VD	SD	CF	CA	FR	BSL	BSR	VPL	VPR	RZL	RZR	TOTAL	PERCENT	CLASSIFICATION
Wood US	4/15/2016	5	15	6	17	16	0	13	10	10	4	5	1	2	104	52.00	Not Supporting
Wood DS	4/15/2016	6	16	7	13	15	0	12	10	10	5	5	8	8	115	57.50	Not Supporting

BSL - Bank Stability (left)
BSR - Bank Stability (right)
CA - Channel alteration
CF - Channel Flow Status
E - Embeddedness

ESC - Epifaunal substrate / available co
FR - Frequency of riffles
RZL - Riparian Zone (left)
RZR - Riparian Zone (right)
SD - Sediment /deposition

VD - Velocity /depth
VPL - Vegetative Protection (left)
VPR - Vegetative Protection (right)
Total - Total Score

Total possible score = 200
Percent - Total/200*100

Classification Scoring

>90%	Comparable to Reference
75.1-89.9%	Supporting
60.1-75.0%	Partially Supporting
<60%	Non-Supporting

APPENDIX A-4

Physical Habitat Assessment Photographs

Project Name: Woodbridge Year 1 Post-construction Monitoring
 Project Number: 1713455603
 Prepared by: CRH
 Prepared date: 10/20/2016

Checked by: AJB
 Checked date: 10/27/2016

BIBI_Coastal_Plain_v4_Woodbridge.xlsx
 Version: 4
 Site Name: WOOD US



Subphylum/ Class	Order	Family	Genus	Final ID	Note ¹	# of Org	FFG ²	Habit ³	Tolerance Value ⁴
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	10	Collector	sp	7
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	1	Filterer	cn	6.5
Crustacea	Copepoda	not identified	not identified	Copepoda	I	1	Collector	0	8
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	P	1	Collector	sp	8.5
Insecta	Diptera	Chironomidae	Diplocladius	Diplocladius	I	10	Collector	sp	5.9
Oligochaeta	Haplotaxida	Enchytraeidae	not identified	Enchytraeidae	I	1	Collector	bu	9.1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	10	Collector	sp	6.1
Oligochaeta	Haplotaxida	Naididae	not identified	Naididae	I	73	Collector	bu	8.5
Insecta	Diptera	Chironomidae	Natarsia	Natarsia	I	1	Predator	sp	6.6
Insecta	Diptera	Chironomidae	Rheocricotopus	Rheocricotopus	I	5	Collector	sp	6.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	3	Filterer	cn	5.7

1 Life Stage, I - Immature, P - Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Project Name: Woodbridge Year 1 Post-construction Monitoring
 Project Number: 1713455603
 Prepared by: CRH Checked by: AJB
 Prepared date: 10/20/2016 Checked date: 10/27/2016

BIBI_Coastal_Plain_v4_Woodbridge.xlsx
 Version: 4
 Site Name: WOOD DS



Subphylum/ Class	Order	Family	Genus	Final ID	Note ¹	# of Org	FFG ²	Habit ³	cb calc (HIDE ME!!)	Tolerance Value ⁴
Oligochaeta	Haplotaaxida	Naididae	not identified	Naididae	I	73	Collector	bu	0	8.5
Insecta	Diptera	Chironomidae	Chaetocladius	Chaetocladius	I	10	Collector	sp	0	7
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	I	3	Filterer	cn	0	6.5
Insecta	Diptera	Chironomidae	Diamesa	Diamesa	I	5	Collector	sp	0	8.5
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	I	5	Collector	sp	0	6.1
Insecta	Diptera	Chironomidae	Eukiefferiella	Eukiefferiella	P	2	Collector	sp	0	6.1
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	Hydropsyche	I	2	Filterer	cn	0	7.5
Insecta	Diptera	Chironomidae	Limnophyes	Limnophyes	I	5	Collector	sp	0	8.6
Gastropoda	Basommatophora	Lymnaeidae	Lymnaea	Lymnaea	I	1	Scraper	cb	cb	6.9
Insecta	Diptera	Chironomidae	Micropsectra	Micropsectra	I	3	Collector	cb, sp	cb	2.1
Insecta	Diptera	Chironomidae	not identified	Orthoclaadiinae	P	4	Collector	0	0	7.6
Insecta	Diptera	Chironomidae	Orthocladus	Orthocladus	I	10	Collector	sp, bu	0	9.2
Insecta	Diptera	Simuliidae	Simulium	Simulium	I	2	Filterer	cn	0	5.7
1 Life Stage, I - Immature, P- Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.										

Project Name: Woodbridge Year 1 Post-construction Monitoring
 Project Number: 1713455603
 Prepared by: CRH Checked by: AJB
 Prepared date: 10/26/2016 Checked date: 10/27/2016

BIBI_Piedmont_v3_LWIN_108.xlsx
 Version: 1
 Site Name: LWIN_108



Subphylum/ Class	Order	Family	Genus	Final ID	Note ¹	# of Org	FFG ²	Habit ³	Tolerance Value ⁴
Insecta	Diptera	Chironomidae	Ablabesmyia	ABLABESMYIA		1	Predator	sp	8.1
Insecta	Plecoptera	Nemouridae	Amphinemura	AMPHINEMURA		13	Shredder	sp, cn	3
Insecta	Coleoptera	Ptilodactylidae	Anchytarsus	ANCHYTARSUS		1	Shredder	cn	3.1
Insecta	Coleoptera	Elmidae	Ancyronyx	ANCYRONYX		1	Scraper	cn, sp	7.8
Insecta	Diptera	Chironomidae	Brillia	BRILLIA		3	Shredder	bu, sp	7.4
Insecta	Trichoptera	Hydropsychidae	Cheumatopsyche	CHEUMATOPSYCHE		9	Filterer	cn	6.5
Insecta	Trichoptera	Philopotamidae	Chimarra	CHIMARRA		4	Filterer	cn	4.4
Insecta	Diptera	Chironomidae	Chironomini	CHIRONOMINI		2	0	0	5.9
Insecta	Diptera	Empididae	Clinocera	CLINOCERA		1	Predator	cn	7.4
Insecta	Diptera	Chironomidae	Diamesa	DIAMESA		1	Collector	sp	8.5
Insecta	Diptera	Chironomidae	not identified	DIAMESINAE		1	Collector	0	7.1
Insecta	Trichoptera	Hydropsychidae	Diplectrona	DIPLECTRONA		1	Filterer	cn	2.7
Insecta	Trichoptera	Philopotamidae	Dolophilodes	DOLOPHILODES		19	Filterer	cn	1.7
Insecta	Diptera	Chironomidae	Eukiefferiella	EUKIEFFERIELLA		1	Collector	sp	6.1
Insecta	Ephemeroptera	Ephemerellidae	Eurylophella	EURYLOPHELLA		1	Scraper	cn, sp	4.5
Gastropoda	Basommatophora	Ancylidae	Ferriisia	FERRISSIA		1	Scraper	cb	7
Insecta	Diptera	Chironomidae	Hydrobaenus	HYDROBAENUS		4	Scraper	sp	7.2
Insecta	Trichoptera	Hydropsychidae	Hydropsyche	HYDROPSYCHE		7	Filterer	cn	7.5
Insecta	Plecoptera	Leuctridae	not identified	LEUCTRIDAE		2	Shredder	sp, cn	0.8
Insecta	Coleoptera	Dytiscidae	Neoporus	NEOPOROUS		1	Predator	sw,cb	5
Insecta	Diptera	Chironomidae	not identified	ORTHOCLADIINAE		3	Collector	0	7.6
Insecta	Diptera	Chironomidae	Orthocladus	ORTHOCLADIUS		11	Collector	sp, bu	9.2
Insecta	Diptera	Chironomidae	Polypedilum	POLYPEDILUM		20	Shredder	cb, cn	6.3
Insecta	Diptera	Psychodidae	not identified	PSYCHODIDAE		1	0	0	4
Insecta	Diptera	Chironomidae	Rheocricotopus	RHEOCRICOTOPUS		1	Collector	sp	6.2
Insecta	Diptera	Simuliidae	Simulium	SIMULIUM		3	Filterer	cn	5.7
Gastropoda	Basommatophora	Lymnaeidae	Stagnicola	STAGNICOLA		1	Scraper	cb	7.8
Malacostr	Amphipoda	Crangonyctidae	Stygobromus	STYGOBROMUS		1	Collector	0	4
Insecta	Diptera	Chironomidae	not identified	TANYPODINAE		1	Predator	0	7.5
Insecta	Diptera	Chironomidae	not identified	TANYTARSINI		1	Collector	0	3.5
Insecta	Diptera	Chironomidae	Tanytarsus	TANYTARSUS		1	Filterer	cb, cn	4.9
Insecta	Diptera	Chironomidae	Thienemannimyia gro	THIENEMANNIMYIA GROUP		1	Predator	sp	8.2
Insecta	Diptera	Chironomidae	Tvetenia	TVETENIA		1	Collector	sp	5.1

1 Life Stage, I - Immature, P - Pupa, A - Adult, U - Undetermined; 2 Functional Feeding Group; 3 Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw - swimmer; 4 Tolerance Values, based on Hilsenhoff, modified for Maryland. An entry of "0" indicates information for the particular taxa was not available.

Scope of Work for Dembytown Monitoring



ISO 9001:2008 CERTIFIED

ENGINEERS • PLANNERS • SCIENTISTS • CONSTRUCTION MANAGERS

936 Ridgebrook Road • Sparks, MD 21152 • Phone 410-316-7800 • Fax 410-316-7885

June 12, 2017

Ms. Michele G. Dobson
Harford County Department of Public Works
212 South Bond St, 1st Floor
Bel Air, MD 21014


RE: Scope of Work and Cost Proposal: Dembytown Stream Restoration Project Monitoring
Harford County Consultant Contract No. 16-073
Open-End Environmental Monitoring
KCI Job No. 161602035.01

Dear Ms. Dobson:

KCI Technologies, Inc. (KCI) is pleased to present our Scope of Work and Cost Proposal to perform five years of monitoring in and around the Dembytown stream restoration project on Foster Branch in Joppa, Harford County, Maryland. This proposal is based on the phone conversation on April 14, 2017, subsequent discussions, and the monitoring requirements laid out by the Baltimore District of the Army Corps of Engineers in a letter dated January 19, 2016. A detailed scope of work and fee derivation with man-hour breakdown are attached for your review. Our proposed fee for this work is **\$54,411.82**.

Thank you for the opportunity to submit our Scope of Work. We look forward to working with you on this project. Should you have any questions about the enclosed material please do not hesitate to contact me.

Very truly yours,
KCI TECHNOLOGIES, INC.



James E. Deriu
Vice President – Natural Resources

Direct Dial: (410) 316-7865
Email: james.deriu@kci.com

Attachments

Dembytown Stream Restoration Monitoring

Scope of Work

Background

Harford County Department of Public Works recently completed a stream restoration project along a portion of Foster Branch in the vicinity of the Dembytown Road stream crossing. The Baltimore District, Army Corps of Engineers authorized the stream restoration under nationwide permit 2015-60430-M37 and is requiring monitoring as a condition of the permit. Information and data collected during the required monitoring activities will be used to assess various success criteria which will be used to evaluate the success of the Dembytown stream restoration project. The Army Corps of Engineers outlined the success criteria and years when monitoring activities should occur in the authorization letter sent to Harford County dated January 19, 2016. The required monitoring from the authorization letter is as follows:

Table 1 – Success Criteria for Stream Restoration

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years
1-Hydrology	Flow	Visual	Exceeds baseline (intermittent or perennial)	PC, 5
2-Hydraulics	Floodplain Connectivity	Bank height Ratio	<1.2	AB, 5
3-Geomorphology	Vertical Stability	Longpro/riffle crest elevations	<0.5 ft thalweg degradation from as-built	AB, 3
	Lateral Stability	BEHI	Moderate or Better	3
	Habitat Assessment	RBP-High Gradient	Greater than Baseline	PC, 3, 5
	Vegetative Cover	% cover	>80% cover in LOD	5
	Rosgen Stream Classification	X-section from riffle crests	Does not classify as G or F stream type	PC, 3, 5
4-Water Quality	NA	NA	NA	NA
5-Biology	Invasive Plant Reduction	% cover invasive species in LOD	Less than Baseline	PC, 5

Table 1 showing performance standards for stream restoration. AB=As-built, PC=Pre-construction, 1-5 corresponds to the monitoring year following construction, NA=Not applicable.

Table 2 – Success Criteria for Wetlands

Level and Category	Parameter	Measurement	Success Criteria	Monitoring Years
Hydrology	Hydrology indicators present	Delineation Form	Wetland Hydrology	5
Soil	Hydric Soils	Alpha-alpha dipyridyl test or hydric soils classification	Hydric soils present or positive reaction with Alpha-alpha dipyridyl	5
Vegetation	Hydrophytic	Delineation Form		5

Table 2 showing performance standards for restored and remediated wetlands. 1-5 corresponds to the monitoring year following construction, NA=Not applicable.

Harford County has requested a scope and fee for KCI to perform monitoring which fulfills the requirements placed on the Dembytown stream restoration project. Also, KCI will produce annual monitoring reports to the County which may be submitted to the Army Corps of Engineers to fulfill the annual reporting requirement.

Schedule

The anticipated schedule for completion of this Scope of Work is as follows:

<i>Early-July 2017</i>	Project kick-off meeting
<i>Previous to Sept 30, 2017</i>	Year 1 monitoring activities
<i>November 15, 2017</i>	Draft Year 1 Monitoring Report
<i><u>December 15, 2017</u></i>	<i><u>Final Year 1 Monitoring Report</u></i>
<i>Previous to September 30, 2018</i>	Year 2 monitoring activities
<i>November 15, 2018</i>	Draft Year 2 Monitoring Report
<i><u>December 15, 2018</u></i>	<i><u>Final Year 2 Monitoring Report</u></i>
<i>Previous to September 30, 2019</i>	Year 3 monitoring activities
<i>November 15, 2019</i>	Draft Year 3 Monitoring Report
<i><u>December 15, 2019</u></i>	<i><u>Final Year 3 Monitoring Report</u></i>
<i>Previous to September 30, 2020</i>	Year 4 monitoring activities
<i>November 15, 2020</i>	Draft Year 4 Monitoring Report
<i><u>December 15, 2020</u></i>	<i><u>Final Year 4 Monitoring Report</u></i>
<i>Previous to September 30, 2021</i>	Year 5 monitoring activities
<i>November 15, 2021</i>	Draft Year 5 Monitoring Report
<i>December 15, 2021</i>	Final Year 5 Monitoring Report

Project Tasks

Task 1: Project Initiation, Coordination

Subtask 1.1: Project Initiation

Within two weeks of receiving the Notice to Proceed, KCI Technologies, Inc. will hold a project kick-off meeting with the County Project Manager and designated County staff to discuss project coordination efforts and schedule of activities. The meeting will last no longer than two (2) hours. Results of the meeting will include a documented meeting summary.

Subtask 1.2: Project Coordination

Project coordination with County staff will be important throughout the course of the work effort. In addition to the project kick-off meeting described above, KCI proposes three meetings to coincide with the completion of substantial draft monitoring reports. Meetings will not be planned for the end of years 2 and 4 as those years have minimal monitoring occurring. These sessions will be necessary to ensure that project work and data collection results meet the County goals and objectives as well as the monitoring requirements set forth by the Army Corps of Engineers. The proposed milestone meetings are:

- At the completion of the Year 1 Monitoring Report (approx. Nov 15, 2017),
- At the completion of the Year 3 Monitoring Report (approx. Nov 15, 2019),
- At the completion of the Year 5 Monitoring Report (approx. Nov 15, 2021).

KCI will prepare an agenda and e-mail it to the Project Manager for input two days prior to the milestone meeting date. Additionally, KCI will prepare meeting minutes to be reviewed first by the County Project Manager, and then distributed by KCI to appropriate Harford County DPW staff.

KCI's project manager will maintain communication with the County's Project Manager, prepare and submit monthly invoices with progress reports, and schedule and direct the performance of the work. The monthly progress reports will be short, bulleted documents providing status updates on the monitoring efforts described above. Such reports will include summaries of any technical problems or issues associated with the monitoring efforts, any interesting or unusual conditions observed in the field, and will document actions planned for the upcoming month. KCI's project manager will be responsible for timely submission of all deliverables for this work effort.

Task 1 Deliverables

- KCI will prepare meeting agendas and meeting minutes for all coordination meetings for the duration of the project.

Task 2: Monitoring

KCI will perform monitoring in and around the Dembytown stream restoration project that fulfills the monitoring requirements as outlined in the Baltimore District, Army Corps of Engineers letter received January 19, 2016.

Invasive Plant and Vegetation Assessments

KCI proposes an annual visual inspection and assessment of the project LOD for the presence of invasive plant species. The Army Corps of Engineers monitoring requirements only specify that this invasive plant inspection be performed in year 5. Performing this inspection annually allows the County to respond quickly to remove any invasive species observed in the project LOD. Waiting until year 5 allows the potential for invasive plants to overrun the project area, making removal at that point more difficult and costly.

The annual invasive plant assessment will document the presence of any invasive plant species within the project LOD and estimate the percent cover of any observed invasive plant species. Photographs will be taken to document the vegetative composition of the site during each annual inspection. Observations made during the current inspection will be compared to previous monitoring data in order to document any changes in coverage of invasive plant species within the project LOD. If invasive plants are observed, KCI will immediately notify Harford County DPW of the species observed the estimated percent coverage. This scope does not cover the development of an invasive species eradication and maintenance plan if annual site visits document their presence. The development of an eradication and maintenance plan would be performed under a separate task order.

During year 5 a final visual inspection of the riparian buffer plantings along the restored channel will be completed to assess the re-establishment and viability of the riparian buffer plantings per the intent of the design. If identified, specific problem areas will be noted on the landscape plans and KCI will document evidence of invasive species, infestation, disease, browsing, mortality, and/or establishment of volunteer species that may have contributed to the problem. This vegetative assessment will produce an estimate of the percent cover of vegetation within the LOD, providing the information needed to assess the success criteria for vegetative cover.

Geomorphology Assessments

KCI will perform geomorphic monitoring in the Dembytown project area. KCI proposes geomorphic monitoring in years 1, 3, and 5. The Army Corps of Engineers monitoring requirements specify that this geomorphological monitoring be performed at the as-built stage, and in years 3 and 5. In KCI's experience, as-built monitoring frequently does not have the level of detail required to assess change over time in vertical and lateral stability of restoration projects. During year 1, KCI will establish permanent monuments on each bank at each cross-section, and also at the top and bottom of the longitudinal profile. These monuments will be used as benchmarks to compare elevations of the cross-sections and profile across years. Standard stream surveying techniques will be used to survey permanently monumented cross-sections and a longitudinal profile at the Dembytown restoration reach.

The longitudinal profile of the restoration reach will be surveyed along the thalweg thread and include riffles, pools, water surface, and (where discernable) bankfull and terrace features. Longitudinal profile surveys are completed to determine riffle/pool sequencing patterns and to determine any changes in channel slope and the extent of any degradation or aggradation that may occur in subsequent surveys. The vertical location of the monumented cross-sections will be tied into the surveyed profile. Photographs will be taken along to profile to document site conditions.

Two cross-section surveys, each located on a riffle, will be completed within the restoration project reach. Each cross-section will be surveyed with a laser level and stadia rod. The cross-sections will include survey of the floodplain, monuments, and all pertinent channel features including:

- Top of bank
- Bankfull elevation
- Edge of water
- Limits of point and instream depositional features
- Thalweg
- Floodprone elevation

Four photographs of each cross-section will be taken; looking upstream at the cross-section, looking downstream at the cross-section, looking from the right bank to the left bank, and looking from the left bank to the right bank.

Data from geomorphic assessments will also be used to determine the stream type for each reach as categorized by the Rosgen Stream Classification methodology (Rosgen, 1996). In this classification methodology, streams are categorized based on their measured field values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials. The Rosgen Stream Classification categorizes streams into broad stream types, which include the following:

Table 3 – Rosgen Channel Classifications

Channel Type	General Description
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.
A	Steep, entrenched, confined, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.
B	Moderately entrenched, moderate gradient, riffle dominated channel with infrequently spaced pools. Moderate width/depth ratio. Narrow, gently sloping valleys. Very stable plan and profile. Stable banks.
C	Low gradient, meandering, slightly entrenched, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks. Active lateral adjustment, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well-vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.
E	Low gradient, Highly sinuous, riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander/width ratio.
F	Entrenched, meandering riffle/pool channel on low gradients with high width/depth ratio and high bank erosion rates.
G	Entrenched “gully” step/pool and low width/depth ratio on moderate gradients. Narrow valleys. Unstable, with grade control problems and high bank erosion rates.

Source: Rosgen, 1996.

The resulting classification will be used as one measure of success of the restoration (see Table 1).

A visual assessment of lateral stability will be performed using Rosgen’s Bank Erosion Hazard Index (BEHI; Rosgen 2001). The BEHI compiles information about the ratio of bank height to bankfull height, root depth, root density, surface cover, and angle of the bank along with adjustments made for bank material type and stratification of bank material (see Table 4).

Table 4 – Bank Erosion Hazard Index, metrics scores and values

Erosion Metrics	Bank Erosion Hazard Index Values						
		Very Low (1.0 - 1.9)	Low (2.0-3.9)	Moderate (4.0 - 5.9)	High (6.0 -7.9)	Very High (8.0 -9.0)	Extreme (10)
	Ratio of Bank Height to Bankful Height	1.0 - 1.10	1.11 - 1.19	1.2 - 1.59	1.6 - 2.09	2.1 - 2.8	>2.8
	Root Depth	1.0 - 0.9	0.89 - 0.50	0.49 - 0.30	0.29 - 0.15	0.14 - 0.05	<0.05
	Root Density	100 - 80	79 - 55	54 - 30	29 - 15	14 - 5.0	<5.0
	Surface Protection	100 - 80	79 - 55	54 - 30	29 - 15	14 - 10	<10
	Bank Angle	0 - 20	21 - 60	61 - 80	81 - 90	91 - 119	>119

The BEHI assessment will be used as one measure of success of the project (see Table 1).

Physical Habitat Assessment

The Dembytown restoration site will be visually-assessed based on physical characteristics and various habitat parameters following the Environmental Protection Agency's Rapid Bioassessment Protocol (RBP) habitat assessment for high gradient streams (Barbour et. al, 1999). Physical habitat assessments will be performed during the geomorphology assessment visits during years 3 and 5.

The RBP habitat assessment consists of a review of ten biologically significant habitat parameters that assess a stream's ability to support an acceptable level of biological health. Each parameter is given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor. Overall habitat quality typically increases as the total score for each site increases. The RBP parameters assessed for high gradient streams are as follows.

RBP High Gradient Parameters

Epifaunal substrate/available cover	Channel alteration
Embeddedness	Frequency of riffles/bends
Velocity/depth regime	Bank stability
Sediment deposition	Vegetative protection
Channel flow status	Riparian vegetative zone width

Stream physical habitat data will be used to assess success of the project when compared against habitat scores from before construction (see Table 1).

Hydrology Visual Assessment

During year 5 KCI will perform a visual assessment of flow and determine if the stream throughout the Dembytown restoration project is intermittent or perennial. The visual assessment will take place during the same visit as the invasive plant and vegetative assessment in July of year 5. This will allow the hydrology to be assessed during the natural low-flow period. This assessment will be compared to preconstruction conditions to measure the success criteria for hydrology. Hydrological conditions will be photodocumented at the time of the assessment. This assessment of hydrology will be used to assess the success of the project when compared against the preconstruction hydrological condition of the site (see Table 1). Visual assessments of hydrology will also be performed during other monitoring activities throughout the five years of monitoring. These additional assessments may prove useful if year 5 falls during a drought year, where the required assessment of hydrology may not reflect the actual hydrological conditions during an average year.

Wetland Assessment

Before the end of year 5, KCI will conduct a site investigation to identify waters of the United States (WUS) and jurisdictional wetlands within the study area in accordance with the "Routine" method outlined in the U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Environmental Laboratory, 2010). Wetland and WUS boundaries will be marked with flagging tape. A GPS will be used to capture the locations of placed flags and markers. A field map will be developed illustrating wetlands and waterway(s) locations and associated flag numbers. Total acres of existing wetlands will be calculated and can be used to document that the project offset any wetlands lost during project construction. The wetlands assessment will be used to assess three success criteria for the restoration project (see Table 2).

Task 3: Data Entry and Analysis

Field data and observations will be managed, and analyzed using appropriate scientific methodology.

Subtask 3.1: Invasive Plant and Vegetation Data

Invasive plant data will be entered into spreadsheets which will contain any species observed and the percent cover of the site.

Subtask 3.2: Geomorphic Data

The stream cross-section, and longitudinal profile data will be partially analyzed using the Ohio Department of Natural Resources Reference Reach Spreadsheet Version 4.3L (Mecklenburg, 2006). A Rosgen Level II classification will be assigned to each cross-section reach. The following values and ratios will be calculated, compared to previous monitoring, and included in the report.

Sinuosity	Entrenchment ratio	Bankfull cross-section area
Slope	Bankfull height	Velocity
Floodprone width	Bankfull width	Discharge
Width / depth ratio	Mean depth	Shear stress

BEHI data will be entered into a spreadsheet which calculates the overall score and assigns a narrative rating to the assessed bank.

BEHI Condition Ratings

BEHI Total Score	Narrative Rating
≤ 7.25	Very Low
7.26 – 14.75	Low
14.76 – 24.75	Moderate
24.76 – 34.75	High
34.76 – 42.50	Very High
42.51 - 50	Extreme

These data will be used detect changes in channel geometry and channel materials distribution over time in this restoration reach. Special emphasis will be placed on vertical and lateral stability.

Subtask 3.3: Physical Habitat Data

Physical habitat data will be entered into an Excel spreadsheet. The 10 individual RBP habitat parameters are summed to obtain an overall RBP assessment score. The total score, with a maximum possible score of 200, is then placed into one of four narrative categories based on their percent comparability to reference conditions (Plafkin et al., 1989).

RBP Physical Habitat Condition Ratings

RBP Score	Narrative Rating
>151	Comparable to Reference
126 – 150	Supporting
101 – 125	Partially Supporting
<100	Non-supporting

Subtask 3.4: Wetland Assessment Data

Wetland assessment data will be recorded on data sheets and digitally using GPS-enabled tablets or hand held GPS units. Data will be entered into standard spreadsheets and GIS databases and or shapefiles. GIS data will be used to produce maps of the wetland delineation for use in the year 5 report.

Task 4: Reporting

KCI will prepare an annual monitoring technical memorandum for monitoring activities completed each year of this scope of work. This technical memorandum may serve as the County's annual monitoring report to the Army Corps of Engineers. A draft technical memo will be emailed to the Harford County DPW Project Manager by November 15th of each monitoring year. Comments will be incorporated into a final technical memo and delivered to Harford County DPW on or before December 15th of each monitoring year.

Annual Monitoring Technical Memo – Year 1 will cover monitoring activities from the summer of 2017 and will contain the results of geomorphology and invasive plant monitoring. Annual Monitoring Technical Memo – Year 2 will cover monitoring activities from 2018 and will contain the results of

annual invasive plant assessment. Annual Monitoring Technical Memo – Year 3 will cover monitoring activities from 2019 and include monitoring results for geomorphology, physical habitat, and invasive plant assessments. The year 3 tech memo will compare geomorphology results between years 1 and 3. Annual Monitoring Technical Memo – Year 4 will cover monitoring activities from 2020 and will contain the results of annual invasive plant assessment. Annual Monitoring Technical Memo – Year 5 will cover monitoring activities from 2021 and include monitoring results for geomorphology, physical habitat, invasive plant, and wetland assessments. The year 5 tech memo will compare geomorphology results from preconstruction, the as-built survey, years 1, 3, and 5 where appropriate. The year 5 memo will also compare the physical habitat assessments from preconstruction, year 3, and year 5. This memo will final project assessment of vegetative cover and identify any invasive plant species located within the project LOD. This memo will also include the results of the hydrology visual assessment and compare those results to the preconstruction condition. The year 5 memo will also compile the wetlands information gathered in the field into a Natural Resources Inventory section that can be utilized for waterway permitting requirements as described below. The description of wetland/stream systems within the project area will include information required by USACE, as specified in their most recent guidance documents and jurisdictional determination checklists at the time of the investigation. Information to be included in the report may include results of the delineation, field data sheets of wetland systems, representative photographs of site conditions and a NRI Map with surveyed wetland boundaries overlain. Data sheets and site photographs will be appended to the text.

Task 5 Deliverables

- Draft Annual Monitoring Technical Memorandum; Years 1, 2, 3, 4, and 5 (digital copy for review)
- Final Annual Monitoring Technical Memorandum; Years 1, 2, 3, 4, and 5 (digital copy)
- Excel Spreadsheets containing all invasive plant, geomorphic, habitat assessment, and wetland assessment raw data, calculations, and results.

References:

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency, Office of Water; Washington D.C.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA 440-4-89-001.

Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. Proceedings of the 7th Federal Interagency Sedimentation Conference, Vol. 2, pp. 9-15, March 25, 2001, Reno, NV. Available on the Wildland Hydrology website at: http://www.wildlandhydrology.com/html/references_.html

Rosgen D. 1996. Applied Fluvial Morphology. Wildland Hydrology. Pagosa Springs, CO.

Harford County Open-End Environmental Monitoring

TASK 1 - Dembytown Monitoring - Years 1 through 5
June 12, 2017

KCI									
Task	Task Description	Principal	PM	Environmental Engineer	Water Quality Biologist	Aquatic Ecologist	Wetland Scientist	KCI Hours	Fee
1	Project Initiation and Coordination								
1.1	Project Initiation and Kick-off Meeting		8			3		11	\$ 1,603.78
	Progress Meetings (3 total, years 1, 3, and 5)		12			9		21	\$ 2,936.94
1.2	General Coordination		40			20		60	\$ 8,609.20
	subtotal hours	0	60	0	0	32	0	92	\$ 13,149.92
	subtotal labor	\$ -	\$ 9,372.00	\$ -	\$ -	\$ 3,777.92	\$ -		
2	Monitoring								
2.1	Year 1								
	Invasive Plant Assessment				8			8	\$ 690.24
	Geomorph			20	22			42	\$ 4,536.56
	subtotal hours	0	0	20	30	0	0	50	\$ 5,226.80
	subtotal labor	\$ -	\$ -	\$ 2,638.40	\$ 2,588.40	\$ -	\$ -		
2.2	Year 2								
	Invasive Plant Assessment				8			8	\$ 690.24
	subtotal hours	0	0	0	8	0	0	8	\$ 690.24
	subtotal labor	\$ -	\$ -	\$ -	\$ 690.24	\$ -	\$ -		
2.3	Year 3								
	Invasive Plant Assessment				8			8	\$ 690.24
	Geomorph			16	20			36	\$ 3,836.32
	Habitat Assessment					2		2	\$ 236.12
	subtotal hours	0	0	16	28	2	0	46	\$ 4,762.68
	subtotal labor	\$ -	\$ -	\$ 2,110.72	\$ 2,415.84	\$ 236.12	\$ -		
2.4	Year 4								
	Invasive Plant Assessment				8			8	\$ 690.24
	subtotal hours	0	0	0	8	0	0	8	\$ 690.24
	subtotal labor	\$ -	\$ -	\$ -	\$ 690.24	\$ -	\$ -		
2.5	Year 5								
	Invasive Plant and Vegetative Cover Assessment				8			8	\$ 690.24
	Geomorph			16	16			32	\$ 3,491.20
	Habitat Assessment					2		2	\$ 236.12
	Hydrology Visual Assessment				2			2	\$ 172.56
	Wetland Assessment						20	20	\$ 1,903.40
	subtotal hours	0	0	16	26	2	20	64	\$ 6,493.52
	subtotal labor	\$ -	\$ -	\$ 2,110.72	\$ 2,243.28	\$ 236.12	\$ 1,903.40		
3	Data Entry and Analysis								
3.1	Invasive Plant (years 1-5)				10			10	\$ 862.80
3.2	Geomorphic (years 1, 3, 5)			2	12			14	\$ 1,299.20
3.3	Habitat Assessment (year 3 and 5)					2		2	\$ 236.12
3.4	Wetland Assessment (year 5)				4		16	20	\$ 1,867.84
	subtotal hours	0	0	2	26	2	16	46	\$ 4,265.96
	subtotal labor	\$ -	\$ -	\$ 263.84	\$ 2,243.28	\$ 236.12	\$ 1,522.72		
4	Task Report								
4.1	Year 1								
	Draft Report		2	4	16	8		30	\$ 3,165.04
	Final Report		1	2	2	2		7	\$ 828.72
	subtotal hours	0	3	6	18	10	0	37	\$ 3,993.76
	subtotal labor	\$ -	\$ 468.60	\$ 791.52	\$ 1,553.04	\$ 1,180.60	\$ -		
4.2	Year 2								
	Draft Report		2		4			6	\$ 657.52
	Final Report		1		1			2	\$ 242.48
	subtotal hours	0	3	0	5	0	0	8	\$ 900.00
	subtotal labor	\$ -	\$ 468.60	\$ -	\$ 431.40	\$ -	\$ -		
4.3	Year 3								
	Draft Report		2	4	16	8		30	\$ 3,165.04
	Final Report		1	2	2	2		7	\$ 828.72
	subtotal hours	0	3	6	18	10	0	37	\$ 3,993.76
	subtotal labor	\$ -	\$ 468.60	\$ 791.52	\$ 1,553.04	\$ 1,180.60	\$ -		
4.4	Year 4								
	Draft Report		2		4			6	\$ 657.52
	Final Report		1		1			2	\$ 242.48
	subtotal hours	0	3	0	5	0	0	8	\$ 900.00
	subtotal labor	\$ -	\$ 468.60	\$ -	\$ 431.40	\$ -	\$ -		
4.5	Year 5								
	Draft Report		2	4	24	8	32	70	\$ 6,900.72
	Final Report		1	2	4	2	8	17	\$ 1,762.64
	subtotal hours	0	3	6	28	10	40	87	\$ 8,663.36
	subtotal labor	\$ -	\$ 468.60	\$ 791.52	\$ 2,415.84	\$ 1,180.60	\$ 3,806.80		
	Subtotal Task - Hours	0	75	72	200	68	76	491	
	Hourly Rate	\$168.89	\$156.20	\$131.92	86.28	\$118.06	\$95.17		
	Labor Subtotal	\$0.00	\$11,715.00	\$9,498.24	\$17,256.00	\$8,028.08	\$7,232.92		\$ 53,730.24
	Summary								
	KCI Labor Fee								\$ 53,730.24
	KCI Direct Expenses								\$ 681.58
	TOTAL								\$ 54,411.82

Harford County Open-End Environmental Monitoring

TASK 1 - Dembytown Monitoring - Years 1 through 5 June 12, 2017

Description	Number	Type	Unit Cost	Extended Cost
Sediment Sampling				
Misc Equipment	1	lump sum	\$200.00	\$200.00
Travel				
Mileage (12 trips at 52 miles, 4 trips at 46 miles)	808	miles	\$0.535	\$432.28
Field maps	10	color 11X17 copies	\$0.98	\$9.80
Draft and Final Report		digital submission		
Misc copies/prints	300	bw 8.5x11 copies	\$0.05	\$15.00
	10	color 11X17 copies	\$0.98	\$9.80
	30	color 8.5x11copies	\$0.49	\$14.70
TOTAL				\$681.58